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Successes of Small Business Innovation Research at NASA Glenn Research Center

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National Aeronautics and
Space Administration

Glenn Research Center

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Note that at the time of research, the NASA Lewis Research Center was undergoing a name change to the NASA John H. Glenn Research Center at Lewis Field. Both names appear in these proceedings.

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Contents

Structures

Microgravity

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Abstract

This booklet of success stories highlights the NASA Glenn Research Center's accomplishments and successes by the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs. These success stories are the results of selecting projects that support NASA missions and also have high commercialization potential. Each success story describes the innovation accomplished, commercialization of the technology, and further applications and usages. This booklet emphasizes the integration and incorporation of technologies into NASA missions and other government projects. The company name and the NASA contact person are identified to encourage further usage and application of the SBIR developed technologies and also to promote further commercialization of these products.

Introduction

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs were enacted by Congress to tap the technical knowledge of small businesses for the nations benefit. The purpose of the SBIR/STTR Programs is to: stimulate technological innovation in the private sector; strengthen the role of small businesses in meeting federal research and development needs; increase the commercial application of the research results; and encourage participation of socially and economically disadvantaged persons and women-owned small businesses. More detailed information on SBIR and STTR Programs are described on web sites: http://sbir.grc.nasa.gov/ and http://sttr.grc.nasa.gov/, respectively.

Maximum funding for NASA's SBIR Phase I contracts is $70K and Phase II contracts is for $600K. Maximum funding for NASA's STTR contracts is $100K and $500K for Phase I and Phase II contracts respectively. If, after Phase II, the innovation received additional research funding from the government or private industry it is considered Phase III. Or, if they commercialize the innovation, the SBIR/STTR is considered a Success Story. Other considerations in identifying successes include: government use, sales and applications, technology transfer, patent, license, company being sold to another company, and spinning off a new company. These successes are highlighted in this document.

SBIR Success Stories are important to NASA Glenn Research Center as a measure of how well we select companies for SBIR contracts. They are also important to NASA Headquarters in their testimony to Congress for continuing authorization of the SBIR Program. This Success Story publication can also identify to both industry and commerce some of the more recent technology available from small business companies. By placing SBIR Success Stories under one cover, as in this report, and indexed by technology areas, the success information is most useful to all interested parties.

Since it is small businesses that conduct high risk, high payoff research, and some are only 2 or 3 person operations, they sometimes need the consideration of the contracting officers. One of the biggest areas of consideration they may have received, is the no cost extension of their Phase II contract. Granting of these extensions made it possible for a few of the companies to become successful where otherwise they would not have been able to bring their work to successful conclusion.

The compilation of success stories are quite labor intensive and a wide variety of sources are utilized in gathering information. Some of this information came from Aerospace Technology Innovation, Spinoff Magazine, Tech Briefs, and other technical and news publications. Information on government use and application usually came from Contracting Officer's Technical Representative (COTR). Otherwise, most information came from contacting all companies that had Phase II SBIR contracts starting chronologically from 1983, the beginning of the SBIR Program.

One member of the technical staff in the SBIR Office was responsible for assembling the Success Stories by contacting the Phase II companies. Once a Success Story was technically complete, the administrative staff put the Success Story in its final form, added figures, obtained releases from the small business companies, and submitted the Success Stories to NASA Headquarters. The administrative staff updated Success Stories by working with the COTRs and the companies, when additional application, usage, or commercialization occurred.

The number of Success Stories collected to date by SBIR Program year is as follows:

SBIR Program Year	Success Stories
1983	4
1984	5
1985	6
1986	4
1987	9
1988	9
1989	9
1990	13
1991	10
1992	15
1993	17
1994	9
1995	6
1996	2
1997	1
1998 (STTR)	1
Total	**120**

All companies from 1983 to 1993 have been contacted, and the Success Stories for those years have been completed. The remaining years are still in progress. In addition to the SBIR Success Stories, a 1998 STTR contract has a Success Story.

The number of Success Stories reported in this document is a few less than the actual number of successful stories because some companies chose to combine two of their related projects into one Success Story. Overall, about 50 percent of the Phase II projects have resulted in successes. This high success rate shows significant success for both the Government and companies. The government success was the infusion of the technologies in major programs and use in research. Company successes were shown by growth from two or three personnel to a large number of employees (50 to several hundred) and significant sales and profit.

NASA Programs and Government Missions

The most important objective of the SBIR projects is to make direct contribution to programs and missions to both NASA and other government departments or agencies. Of the many government uses and applications of the SBIR projects, two projects in particular made significant contributions and are noteworthy as prime examples. One was for a space program by Entech, Inc., and another was in aeronautics by Cox & Company, Inc.

Entech, Inc. developed a “Fresnel Lens Gallium Arsenide Photovoltaic Concentrator Lens” that was used in the Deep Space 1 Program. Deep Space 1, the first flight under NASA’s New Millennium program, was launched in October 1998. One of the primary mission goals was to test and validate a dozen cutting-edge technologies for use on future spacecrafts. The performance of Deep Space 1 was excellent and lasted for several years. Just recently, the program was completed.

Cox and Company, Inc. developed a new methodology for ice protection that combines electro-thermal anti-icing with electro-mechanical expulsion deicing to maintain leading edges of aircraft clear of ice. This technology received Federal Aviation Administration (FAA) certification on May 23, 2001. This ice protection system is being used on Raytheon Aircraft’s new Premier I business jet.

Although, only these two examples were noted, there are many others that made significant contributions as reported in Table I. Table I lists 78 companies, the contracts, and the contributions that were made to both NASA and other government programs and missions. This is over 70 percent of the successes.

Biotechnology

Some SBIR successes from NASA Glenn Research Center’s SBIR projects have been identified for specific application outside of NASA and the Department of Defense. One area is Biotechnology/Biomedical/Quality of Life. Table II identifies these SBIR projects along with a brief description of how they relate to improving health and better quality of life.

Summary

This report shows that the SBIR Program at the NASA Glenn Research Center at Lewis Field has been very effective. Much of this success can be attributed to the subtopic managers, the reviewers, and the SBIR Board in obtaining good proposals and selecting some of the best ones for contract award. The SBIR Program makes direct contributions to NASA and government missions. And, the SBIR results are applied and commercialized in the private market sector.

Table 1
NASA and Government Programs and Missions

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Advanced Ceramics Corporation Cleveland, OH 5130/Serene Farmer	Durable Interface Coatings for Ceramic Matrix Composites	27690	1993	Major impact on the Enabling Propulsion Materials Program of High Speed Research showed that the new interface coatings are more than 1,000 times more durable than the state-of-the-art.
Advanced Projects Research Laverne, CA 0142/Doug Perkins	Enhanced Combustion Pulsejet Engines (ECPJ) for Mach 0 To 3 Applications	97028	1995	Company received a Phase III contract NAS3-97108 for $33K from drone manufacturer during Phase II. Advanced Project Research demonstrated ignition system for a pulsejet and built and tested an advanced pulsejet engine. NAVY and USAF are also funding the development of related technology.
Advanced Research and Applications Corp. Sunnyvale, CA 5920/George Baaklini	Large Area Detector for Radiographic Measurements	26986	1991	Detector technology incorporated into the Konoscope volumetric x-ray computed tomography systems. Konoscope sales have reached almost $2,500,000. The sales were to Wright Patterson Air Force Base and the University of Utah.
Aerodyne Research, Inc. Billerica, MA 5520/Mark Wernet	Turbomachinery Flowfield Temperature Measurement Linear Imaging Diagnostics	27000	1991	This technique will be used in the “Smart Green Engine” Program and will be used in the NASA Physics and Process Modeling Program (PPM). The technique is useful in turbomachinery research over a temperature range of 300K - 500K.
Aerodyne Research, Inc. Billerica, MA 5520/Richard Seasholtz	High Temperature Combustion Diagnostic Method Utilizing Rayleigh Scattering	24613	1983	A system was delivered to NASA Glenn Research Center where is was successfully used on a research combustor. The technique and research results were passed-on to Polytechnic University and Air Force Wright Laboratories for use in temperature and turbulence studies of gas flows.
Aerodyne Research, Inc. Billerica, MA 5160/Maria Kuczmarski	Optimization of Silicon Carbide Production	24891	1984	Aerodyne received a related SBIR from the Air Force Office of Scientific Research (AFOSR). The code was used by NASA to optimize production of single crystal semiconductors for high temperature electronic devices. Company received $25K in development funding from the Navy and $35K in commercial sales.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Aerometrics, Inc. St. Paul, MN 0160/Valerie Lyons	Phase Doppler Particle Analyzer	25204	1985	This system was used in the characterization of particle fields by NASA's Icing Technology Division. Program uses include Advanced Subsonic Transport (AST) and High Speed Research (HSR).
Aerometrics, Inc. St. Paul, MN 6510/Mark Klem	Simultaneous Measurement of Temperature, Size, and Velocity of Drops In Sprays	26248	1989	Government programs include; High Speed Research (HSR), Advanced Subsonic Transport (AST), icing and in rocket injector research and gas turbine combustion. Prototype rainbow thermometer delivered to Lewis and integrated with existing two component Phase Doppler Particle Analyzer.
Aerometrics/TSI, Inc. St. Paul, MN 7560/John Oldenburg	Advanced Instrumentation for Aircraft Icing Research	25635	1987	Company received a Phase III contract NAS3-97108 for $33K from drone manufacturer during Phase II. Phase Doppler technique was successfully adapted to cloud droplet size and velocity measurements. This instrument was successfully tested in the NASA Glenn Research Center Icing Tunnel. An advanced Phase Doppler signal processor was developed under a $150K Phase III effort with GRC. Uses include certification of commercial aircraft and cloud physics studies, including in-flight tests.
AI Ware, Inc. Independence, OH 5930/Shantaram Pai	Design of Experiments Module	26657	1990	The computer program which incorporates artificial intelligence can be applied to any experimental designing used in the scientific and research communities. This method is presently being used in Glenn Research Center's Structural Analysis Program and at Wright Patterson Air Force Base in the composites area.
Alpha STAR Long Beach, CA 5000/Christos Chamis	Concurrent Probabilistic Simulation of High Temperature Composite Response	26997	1991	Product was commercialized under the trade name GENOA and had steady increase in revenue since 1996. This software system has been used by NASA, USAF, and FAA.
Alpha STAR Long Beach, CA 5000/Christos Chamis	GENOA/Progressive Failure Analysis (GENOA/PEA) Software System	97041	1995	Received NASA software of the Year Award for 1999. For use in government applications include NASA White Sands, NASA LaRC, NASA GRC, USFA, FAA and NIST.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Applied Research Associates Raleigh, NC 5930/Dale Hopkins	Portable Parallel Stochastic Optimization for the Design of Aeropropulsion Components	27288	1992	The company obtained a $750K Air Force SBIR contract to make program more user friendly and received $25K contract from Langley Research Center for special program customization. Commercially sold six copies of the program for $10K.
Aurora Flight Sciences Corporation Starksville, MS 5940/Richard Woodward	Single Lever Power Control for General Aviation and Unmanned Aircraft	27814	1994	Currently being used in NASA's AGATE (Advanced General Aviation Transport Experiment) for integrated flight tests with all-digital cockpit technology components. Potentially used in NASA's ERAST (Environmental Research and Atmospheric Science Technology) UAV Program.
Brimrose Corporation of America Baltimore, MD 6712/Walter Duval	Novel Photorefractive Material ZnTe:V for Optical Processing	26983	1991	As a result of the SBIR the company received follow-on funding of almost $1M from DOD for applications of ZnTe: $830K Air Force Phase I and II SBIR, $99K ARPA Phase I SBIR and $66K for Air Force White Paper contract. Brimrose used ZnTe in a novel photo-emf signal processor and received $830K from Army Phase I and II SBIR contracts for this spin-off. A NASA sponsored research project with MetroLaser in Irvine, California used this material to demonstrate resonant holographic interferometric spectroscopy.
Cadetron, Inc. Atlanta, GA 5210/Laszlo Berke	Autosolid	25150	1985	Autosolid has been used in NASA Glenn's structural analysis research. Innumerable applications for product design within the AutoCAD system.
Ceramic Composites, Inc. Annapolis, MD 5320/Steven Schnieder	Oxidation Resistant HFC-TaC Rocket Thrusters for High Performance Propellants	27272	1993	Hypersonic vehicle propulsion components are presently being evaluated under the DARPA HyFly Program. Divert and attitude control propulsion thrusters are presently being tested under BMDO and AF programs. Received $140K Phase III from MSFC.
CFD Research Corp. Huntsville, AL 5830/Nan-Suey Liu	Unstructured Density Based CFD Methodology for Gas Turbine Combustor Applications	27632	1993	CFD-GEOM is being marketed as a stand-alone product for structured and unstructured grids, as well as in conjunction with CFDRC flow solvers. Several Phase III extensions by NASA and CFDRC with NASA contributing $375K.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Cirrus Design Corp. Duluth, MN 5840/Thomas Bond	Low Cost Electromagnetic De-Icer for Natural Laminar Flow Airfoils	27646	1993	Important to NASA as part of the General Aviation Revitalization Program. Important to the military for tactical unmanned aerial vehicles. Demonstrated performance with full-scale ice protection models in wind tunnel tests.
Conax Buffalo Technologies L.L.C. Buffalo, NY 2540/Robert Baumbick	Blackbody High Temperature Optical Sensor	25451	1986	Hardware was developed for the NASA Fiber Optic Control Systems Integration (FOSI) Program.
Cox & Company, Inc. New York, NY 5840/Andy Reehorst	Economical Hybrid Anti-Icing System	97031	1995	The Hybrid Anti-Icing System was tested at NASA Icing Research Tunnel by Cox and Raytheon Engineers. Company received FAA certification on May 23, 2001.
Creare, Inc. Hanover, NH 6710/Robert Friedman	A Capacitive Void Fraction Instrument for Two-Phase Flow in Microgravity	26552	1991	Used in microgravity science mission aboard the NASA KC-135 aircraft: to measure flow characteristics in a refrigerant loop by NASA GRC Microgravity Division and to measure flow characteristics in R-134a and R-12 refrigerant loops by NASA JSC Crew and Thermal Systems Division (with Texas A&M University).
DAAT Research Corporation Lebanon, NH 5830/Nan-Suey Liu	Advanced CFD Tools for Designing Combustion Systems & Materials Processing	27251	1992	NASA will use this technology in support of the High Speed Research (HSR) and Microgravity Programs.
Deformation Control Technology, Inc. Cleveland, OH 5100/William Brindley	A Software Tool to Design Thermal Barrier Coatings	27539	1993	In support of NASA HITEMP and Hybrid-Hyperspeed programs.
ElectroChem, Inc. Woburn, MA 5420/Patricia Loyselle	High Efficiency Proton Exchange Membrane Fuel Cell	27242	1992	Study of fuel cell operation in upper atmospheric scientific balloon for NASA Wallops' Balloon Program. Commercial sales of $53K for several units to NASA for use in atmospheric studies as part of a SBIR Phase III.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Electroformed Nickel Huntsville, AL 5430/Robert Jankovsky	High Temperature Oxidation-Barrier Coatings for Refractory Metals	26256	1989	Using the iridium coating over rhenium substrates prototype radiation cooled attitude control thrust engines, such as would be employed in satellites for maneuvering, accumulated hot firing cycle life to 14 hours at 3400 °F, has been demonstrated by NASA Lewis. USAF Philips Laboratories has shown as interest in this coating process for rocket nozzle inserts to extend the life and range of missile devices. Such an insert was fabricated and successfully fired by Edwards AFB.
Electroformed Nickel Huntsville, AL 5830/Tim Smith	Electroformed Structural Copper and Copper Alloys for Rocket Components	27386	1992	Aerojet has employed ENI's fine grained copper in the fabrication of full-scale formed platelet thrusters for Aerojet's Rocket Based Combined Cycle engine in support of Marshall Space Flight Center's Advanced Reusable Technologies Program. Aerojet is also investigating the use in ENI's fine grained copper for forming hotgas walls for combustion chamber liners. To date $17K of these new materials have been sold to NASA Glenn Research Center. NASA Tech Brief articles of the new materials have been written.
EMC Technology, Inc. Cherry Hill, NJ 5640/Gerald Chomos	Passive Temperature Compensating Attenuator	27656	1993	EMC developed a high Temperature Coefficient of Resistance (TCR) thick film material with high frequency attenuator designs and automated high frequency measurement development. EMC developed Power sensing Termination (SmartLoad). The components are currently flying on four military and commercial satellite programs including: IRIDIUM, Motorola telecommunications satellite, VMISAT, European meteorological satellite, INTELSAT, Global Star telecommunications satellite, INMARSAT, Lockheed Martin telecommunications satellite.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
ENTECH, Inc. Keller, TX 5410/Michael Piszczor	Fresnel Lens Photovoltaic Concentrator Array	25192	1985	NASA/USAF/Boeing PASP (Photovoltaic Array Space Power plus Diagnostics) experiment flown in 1994-first successful demonstration of ENTECH lens concept in space. BMDO/NASA Glenn SCARLET 1 Array successfully built and space qualified for METEOR satellite. 2,600 watt SCARLET 2 array to provide power for JPL's New Millennium Deep Space One Mission launch in 1998.
Epsilon Lambda Electronics Corporation Geneva, IL 5640/Afroz Zaman	RF Components for Satellite Communications System-Active Phased Arrays	27412	1992	A $750K Air Force contract was awarded to develop a W-band (76 GHz) phase scanned antenna with transceiver for automotive forward looking radar market for use in intelligent cruise control. Company received $1.2M under Fast Track funding for a companion commercialization contract. The principle of the innovation was demonstrated in the 64 element scanned array antenna that was delivered to Glenn Research Center.
Exfluor Research, Corp. Austin, TX 5960/William R. Jones	Perfluoropolyether Lubricating Fluids	24856	1984	Received $750K Air Force contract for optimizing a chemical structure for use in high performance jet engines. Useful in the electronic industry and in Space Shuttle and high performance aircraft where lubricants are required that have a wide liquid range and a low volatility.
Expert Microsystems, Inc. Orangevale, CA 6510/June Zakrajsek	Real-Time Sensor Validation	27484	1994	Under development for real-time Space Shuttle telemetry data analysis and NASA mission operations support. Under evaluation for military aeropropulsion system data monitoring.
Foster-Miller, Inc. Waltham, MA 5150/Mike Meador	Non-Toxic, Resin Transfer Molding (RTM) Processable, High Temperature Matrix Resin	27532	1994	Foster-Miller developed, matrix resin system by combining reactive diluents with the NASA developed AMB-21 polyimide resin. Sample materials provided to McDonnell-Douglas, Dow-UT NASA, and GE Engines, for testing and evaluation.
Foster-Miller, Inc. Waltham, MA Karl Baker	Lightweight Graphite/Aluminum (Gr/Al) Structural Space Radiators for Thermal Management	27385	1992	The Army funded a program for $500K to place inserts in MMC components. Samples of MMC electronics substrates are being supplied to government prime contractors for evaluation

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Geo Centers, Inc. Newton Center, MA 0620/Kenneth Bowles	Fiber Optic Systems for Composite Process Monitoring and Control	25817	1987	Important to NASA's Aeronautics High Temperature Materials (HITEMP), High Speed Civil Transport (HSCT), and Enabling Propulsion Materials (EPM) Programs. Received commercial DOE and DOD funding totaling $250K (PHsIII). Important to all military advance propulsion engine programs.
Innovative Dynamics, Inc. Ithaca, NY 5840/Andrew Reehorst	Ice Detection Sensor System	25966	1988	Research Supported by Icing Technology Branch within NASA Glenn Research Center Piper Malibu Featured at September 1994 Technology Open House at Glenn Research Center.
International Solar Electric Technology Inglewood, CA 5410/Henry Curtis	Light-Weight Flexible Thin Film Solar Cells for Space Applications	26615	1993	Work led to an Air Force-supported project that resulted in the demonstration for the first time of CIS solar cells with over 1kW/kg power density on polymeric substrates. Received innovation award from NASA. Received $3M Advanced Technology Program contract for communications applications of these devices.
Iowa Thin Film Technologies, Inc.	Flexible, Lightweight, Amorphous Silicon Solar Cells Tuned for AMO Spectrum	26244	1989	Phase III monies totaled $4.7M from several government and private sources. The DOE National Renewable Energy Labs (NREL) is the largest government contract. Companies evaluating our materials for space applications include Lockheed-Martin and TRW, which includes testing in space.
JX Crystals Inc. Issaquah, WA 5410/Michael Piszczor	30-Percent Efficient, Tandem Solar Cells for Line-Focus Photovoltaic Array	27240	1992	This SBIR served as a major stepping-stone in receiving a Ballistic Missile Defense Organization (BMDO) 1997 SBIR managed by GRC (NAS3-00122). They received Army SBIR, Army STTR and DARPA SBIR contracts for further work on GaSb thermophotovoltaic cells for terrestrial military applications. They received two Department of Energy (DOE) contracts for terrestrial applications of the GaSb photovoltaic cell. Also applicable to many military missions for space power generation and terrestrial stand-alone TPV systems.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Kulite Semiconductor Products, Inc. Leonia, NJ 5510/Lawrence Matus	6H-SiC Pressure Sensors for High Temperature Applications	27011	1991	A Phase III contract was awarded, (NAS3-99099) for $500K to provide GRC with 6-10 prototype SiC Pressure sensors. Funding by Advanced High Temperature Engine Material Technology Program (HITEMP) and Higher Operating Temperature Propulsion Components (HOTPC) Program. A prototype SiC pressure sensor was successfully tested at Honeywell in Phoenix, AZ in September 2000 and at P&W, Florida on a PW2098 engine in August and September, 2001.Test was part of a GRC's EVNRC (Engine Validation of Noise Reduction Concept) program.
Lambda Research Cincinnati, OH 5120/Timothy Gabb	Surface Enhancement Method for Improved Fatigue Life of Superalloys at Engine Temperatures	99116	1997	Company demonstrated LPB on advanced disk superalloys, assisted by NASA Ultrasave Propulsion Project. NASA SBIR laid the ground work for a SBIR with NAVAIR.
LiteCom, Inc. Canoga, CA 6728/Amy Jankovsky	Fiber Optic Cable Feedthrough and Hermetic Sealing for Aerospace Environment	26611	1990	Provided hermetically sealed underwater connectors for use with Navy submarines, submersibles, and remotely operated vehicles. Provided fiber optic hermetic sealed connectors for Sandia Laboratory. Potenial for Space Station applications.
Makel Engineering, Inc. Chico, CA 5510/Gus Fralick	Robust Exhaust Gas Sensing System Using Advanced Thin Film Chemical Sensors	00107	1998	Company received Phase III funding of $170K from NASA Glenn. Applications include; jet engine emissions monitoring for NASA; Arnold Engineering and Develop. Center/U.S. Air Force for performance measurements in exhaust of vectored jet engines with afterburner; EPA and DOE for NOx measurements of diesel engines.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Maverick Corporation Cincinnati, OH 5150/Michael Meador	Safe Polyimides for Low-Cot Processing of High-Temperature Composites	98024	1996	These novel polyimides can be manufactures from fabric or braid using a variety of processes including: autoclave, solvent-assisted Resin Transfer Molding (RTM), and compression molding. Complex parts produced include LH2 Test Duct for Reusable Launch Vehicles, High Pressure Cooling Tube, Center, Vent Tubes, and Stator Vane Bushings. GRC contributing $50K for this effort. Other supporters include Air Force, GE Aircraft Engines and BF Goodrich contributing a total of $125K.
Metal Matrix Composites Cambridge, MA 5120/Michael Nathal	Pressure Infiltration Casting of Superalloy Composites	27541	1993	Will be used for the Boeing Spaceway satellite system that will be launched in 2002 and the Boeing wireless military communication system.
Microwave Monolithics Simi Valley, CA 5610/Robert Kerczewski	High-Efficiency, Low Cost, GaAs Monolithic RF Module SARSAT Distress Beacons	25712	1987	Microwave Monolithics invested $1.2M of company resources after completion of Phase II and developed a complete MicroPLB SARSAT Beacon. Commercial sales of this and related technology devices exceeded $1.1M to date, and additional government sales of $300K directly resulted from the phase II effort. The MicroPLB is a vital safety device for Military and Civilian Government personnel, Providing rapid world wide notification and location information is case of emergency.
Microwave Monolithics Simi Valley, CA 5660/Gene Fujikawa	Advanced Monolithic GaAs IF Switch Matrix	24252	1983	Awarded a Phs III contract NAS3-25713 for $1.234M. A 3X3 MMIC intermediate frequency (3.0 - 6.0 GHz) switch matrix was developed and delivered to NASA. Received a Phs III contract for $1.23M to develop a fully integrated 6X6 switch matrix, contributing to the post-ACTS technology by reducing weight, complexity, and power use.
Moller International Davis, CA 5830/Chi-Ming Lee	Special Coatings in a Rotary Engine	26309	1989	Manufacturability of the Rotapower engine was significantly enhanced under a contract with the USAF Sacramento Air Logistics Center. A subsequent SBIR contract with the U.S. Army proved that the Rotapower engines operate very effectively using diesel fuel.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Nektonics, Inc. Cambridge, MA 7555/Bruce Rosenthal	Tool for Coating Process Simulation	26725	1990	Software was used in the Surface Tension Driven Convection Experiment (STDCE), a low gravity fluid physics experiment flown on STS-50, June 1992 and STS-73, October 1995.
Orbital Technologies Corporation Madison, WI 5830/Bryan Palaszewski	Metallized Cryogen for Advanced Hybrid Engines	27382	1992	Received follow on funding of $930K from the Air Force Research Lab and NASA Marshall for testing solid oxygen/liquid hydrogen. Received a NASA Research Announcement contract from NASA Glenn for $490K to test solid carbon monoxide/liquid oxygen. Received from NASA Goddard/Universities Space Research Assn. a Phase I & II NASA Institute for Advanced Concepts contract for $75K and $465K respectively, to compare solid methane/liquid oxygen, solid carbon monoxide/liquid, and other propellants.
Penn Laboratories, Inc. Anniston, AL 5100/James DiCarlo	Innovative Laser Furnace	26663	1990	Being applied to NASA's Advanced High Temperature Materials Program (HITEMP), in Enabling Propulsion Materials, (EPM) Program, and a part of the High Speed Research Program (HSR).
Penn Laboratories, Inc. Anniston, AL 5120/Leonard Westfall	Laser Float-Zone Process Improvements	25944	1988	Technology applied in NASA's High Temperature Engine Material Program (HITEMP).
Physical Sciences, Inc. Andover, MA 5410/David Snyder	Arc Reduction Procedures for Solar Cells	25797	1987	NASA purchased test panels for $15K which were tested successfully on Space Shuttle STS-62.
Physical Sciences, Inc. Andover, MA 5420/Richard Baldwin	Electrocatalysts for High Efficiency Solid Polymer Electrolyte Fuel Cell	26699	1990	Phase III funding of $190K obtained from the Department of Energy and the State of Florida. Applications include long term Lunar and Mars missions, underwater autonomous vehicle propulsion, and terrestrial remote, and portable power.
Power Technology South (PTS) Company Raleigh, NC 5450/Gene Schwarze	Pulse Power Thyristors (PPTS) for Aerospace	27553	1993	New Government and Commercial Turbine starters use the new PPT Technology. Stacks of PPTs are used to replace Thyratron tubes. PPT stacks are also used to initiate Inertial Confinement Fusion in the NRL Electra application.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Precision Combustion New Haven, CT 5830/Chi-Ming Lee	Catalytic Ignition for Rotary Combustion Engines	25784	1986	Advances in program led to developments in catalytic ignition systems receiving $2.6M in further R&D investment from both government and commercial sources. Enabled further catalytic combustor advances by Precision Combustion, for DARPA, NASA, US ARMY, and USAF. PHS III investments of more than $300K. Technology enabled further catalytic combustor advances by Precision Combustion, Inc. for DARPA, NASA, US Army and USAF.
Program Development Company White Plains, NY 5940/Ray Gaugler	Turbo with Automatic Zoning (GridPro))	26311	1989	The company integrated the grid software with the NASA CFD codes Glenn HT and WIND, also provided the critical link for high fidelity CFD analysis to be applied to realistic configurations for industry and government applications. GridPro has been purchased for use by NASA Glenn and Ames. For at least five years, Glenn has paid the company $20K per year for a total of $100K for upgrade and maintenance of this software.
Science Research Lab Somerville, MA 5430/Steven Schneider	Multiple Beam Spectroscopy for Liquid Rocket Engine Diagnostics	27001	1991	Complete instrument, and calibration equipment delivered to NASA Glenn for study of rocket engine exhausts. An instrument is on loan to Microcoating Technologies, who are marketing a novel combustion coating system for possible inclusion in the control system of their product. Based on this SBIR an instrument was fabricated and delivered to the Plasma Fusion Center at MIT and used for diagnostics on the Alcator Tokamak. Such measurements were made for NASA Langley and for Arnold AFB. SRL has now proposed to deliver a velocimeter to the FHWA to map the air flow in their wind tunnel.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
SI Diamond Technology, Inc. Austin, TX 7760/Todd Tifil	Autonomous Leak Detection for Orbiting Spacecraft	25971	1988	The University of Houston's Space Vacuum Epitaxy Center purchased two TOF-MS for use in the Weight Shield Facility Program. As part if the Weight Shield Facility Program the TOF-MS flew on three Shuttle flights in a control loop to monitor atomic oxygen and atomic hydrogen impurities for a process to improve thin film gallium arsenide production. The Shuttle flights were STS-60 (Discovery, Feb.94), STS-69 (Endeavor, Sept.95), and STS-80 (Columbia, Nov.96).
SiCom, Inc. Scottsdale, AZ 5650/Nam Nguyen	Innovative High Speed Modem for Satellite Communications	27824	1994	Baseline modem for the NASA GRC Direct DATA Distribution (D3) project. Applicable to International Space Station and Earth Science missions which require wideband data service. BitFLOW will be used at Sandia Labs. Other interested government agencies; DARPA,NRO,DISA,USSPACECOM, and CECOM.
Sol-3 Resources, Inc. Reading, MA 5830/Robert Tacina	Gas Turbine Combustor for Low Pattern Factor and Low NOx Emissions	26057	1988	This NASA SBIR served as a stepping stone for successful Army Phase I & II contracts. Following the Army SBIR an Air Force SBIR was successfully completed. This has resulted in discussions with the Air Force for a Potential Phase III.
Solar Kinetics Dallas, TX 5440/Joseph Savino	Improved Mirror Facet	25632	1987	Government uses include; Space Station, advanced space telescopes and lightweight antenna dishes. Very efficient, high concentrator is important to NASA's Solar Dynamics Program for both space and terrestrial application.
Southwest Sciences, Inc. Santa Fe, NM 6711/Paul Greenberg	Near-Infrared Diode Laser Microgravity Combustion Diagnostic	25981	1991	This system is currently being used by NASA to measure combustion gas concentrations in its drop tower facility at GRC. Newer systems now under development could be used in the International Space Station and other spacecraft for both research studies and as fire safety monitors.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Spire Corporation Bedford, MA 5410/Dennis Flood	High efficiency, Radiation-Resistant Indium Phosphide Solar Cells	24857	1984	Long-life, reliable photovoltaic power for commercial, military, and NASA satellites in, medium-to-high radiation environments (e.g., MEO,GEO,or high LEO). Spire Corporation achieved world record conversion efficiency (>19%) for indium, phosphide (InP) cells. Confirmed radiation hardness by actual flight experiment Photovoltaic Array Space Power Plus Diagnostic (PASP-Plus). Led to successful NASA and Navy-sponsored cell development programs using 90% less expensive silicon substrates. Applications include long-life, reliable photovoltaic power for commercial, military, and NASA satellites in medium-to-high radiation environments (e.g.MEO,GEO, or high LEO).
Spire Corporation Bedford, MA 5410/Dennis Flood	Indium Phosphide Solar Cells on Silicon Substrates	25798	1987	Flight panel currently under construction for a high radiation mission Space technology Research Vehicle (STRV 1-C/D) being funded by a $370K Navy contract. NASA sponsored program led to an additional Navy sponsored advanced development.
Stirling Technology Company (STC) Kennewick, WA 5490/Lanny Thieme	Stirling Convertor for a Radioisotope Power System	27817	1994	STC has generated over $9M in commercial revenue and received Phase III funding of $3.3M to date plus $2M backlog and more than $17M pending from DOE and NASA for the radioisotope space power application. This SBIR led to major DOE/NASA project to develop Stirling RPS . Near term high-efficiency RPS for NASA deep space mission and enabling technology under consideration for Mars rovers for long duration missions.
Structural Analysis Technologies, Inc. Santa Clara,CA 5210/Laszlo Berke	AUTODESIGN	25642	1987	Approximately 150 copies of AUTODESIGN were sold by Structural Analysis Technologies, with sales totaling nearly $1M. SAT, together with AUTODESK and a third company, won a $900M Navy software contract. Lewis and Edwards AFB used this in the design of new generation aerospace structures. Also used by Hughes Aircraft, TRW, Applied Materials, Lockheed, Sandia Labs, and Kelly AFB for mechanical and aerospace design.

Table 1
NASA and Government Programs and Missions (Continued)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Sunpower, Inc. Athens, OH 5460/Roy Tew	Measuring Reversing Flow Pressure Drop in Stirling Engine Heat Exchangers	24879	1984	Stirling engines are a leading candidate for dynamic space power systems. Stirling has been chosen as a backup for the Advanced Radioisotope Power System (ARPS) being developed for deep-space missions.
Synchrony, Inc. Roanoke, VA 5230/Gerald Brown	Magnetic Bearing System for Gas Turbine Engines	27551	1993	Technology is currently used in Department of Defense programs to develop Advanced Turbine Engine Gas Generator (ATEGG).
Technology Management Cleveland, OH 5420/Mark Hoberecht	Regenerative Solid Oxide Fuel Cell Technology Development	27546	1993	Continued support from both commercial contracts; EPRI and GRI, and government contracts DARPA, Navy, NASA, USDA, DOE to serve multiple portable and stationary applications operating multiple fuels including military logistic fuels and biogas.
TECSTAR City of Industry, CA 5410/Sheila Bailey	26 Percent Efficient, Triple Junction Cascade Space PV Solar Cells	27674	1994	TECSTAR delivered four flight qualified multijunction solar panels to NASA for $100K contract price. Will fly on NASA/DOD/DERA STRV-C/D Satellites in year 2000. The temperature and radiation characteristics of these solar cells are advantageous for near sun missions and high voltage operation. Phase III funding of $100K.
The Technology Partnership Grosse Ile, MI 5950/Robert Fusaro	High Reliability Long-Term Lubricators	26844	1992	Lubricator has the potential to make substantial improvements in maintenance costs and reliability of U.S. Army tactical vehicles. Subsequent Phase I and II SBIR awards from both Army Tank Automotive and Armaments Command (TACOM) and the Air force based on shrink-polymers.
TiNi Alloy Company San Leondro, CA 2500/Douglas Rohn	A Low-Cost, Compact, Non-Explosive Pin Puller for Aerospace Applications	27292	1992	Applications include Hold Down and Release of numerous satellite deployables including solar panels, communication antennae, instrument cover doors, radiators, heat shields, tether experiments, isolation system and numerous others. Was used aboard the Mars Global Surveyor and Lunar Prospector.

Table 1
NASA and Government Programs and Missions (Concluded)

Company City, ST Org.Code/COTR	Title	NAS3-	Year	NASA Mission or Government Program Use
Ultramet Pacoima, CA 5320/Steven Schneider	High Temperature Oxidation-Resistant Thruster Materials	25203	1985	NASA, TRW/Lockheed Martin, Kaiser Marquardt/ Hughes, Aerojet, and Ultramet have invested nearly $25M to develop this product. Flight qualified and successfully flown on space on the Hughes Orion 3 Spacecraft. Received $402K in Phase III funding from the On-Board Propulsion Branch at NASA Glenn.
Ultrasystems, Inc. Irvine, CA 5960/William R. Jones	Perfluoropolyether Fluids as High Temperature Lubricant	24632	1983	Ultrasystems received two Air Force contracts, one worth $600K. This fluid is used in satellite guidance systems including Geostationery Operational Environmental Satellites (GOES); Television Infrared Observation Satellite (TIROS); Earth Radiation Budget Satellite (ERBE); LANDSAT series.
Ultramet Pacoima,CA 5930/Shantaram Pai	High Temperature Turbine Blades	25650	1987	Ceramic-to-metal joints fabricated for BMDO/Army Theater High Altitude Air Defense System (THAADS), with $750K in sales to date to propulsion contractor Rocketdyne. Ceramic-to-metal joints fabricated for DOE/Navy submarine nuclear reactor program, with $500K in sales to (GE/Knolls Atomic Power Labs).

TABLE II
SBIR PROJECTS WITH APPLICATIONS IN BIOTECHNOLOGY/BIOMEDICAL/QUALITY OF LIFE

January 2002

Aerometrics, Inc.

Phase Doppler Particle Analyzer
Sunnyvale, CA

The spray nozzle development has been used for fuels, paints, agricultural materials, and medical nebulizers thus having a medical application. This non-intrusive device was selected for the International Tanasawa Award. This project generated more than $25M in commercial sales and has provided 120 jobs. Published in Spinoff 98.
COTR – Valerie Lyons

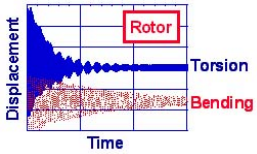
AI Ware, Inc.

Design of Experiments Module
Independence, OH

This project has representative users and applications in the pharmaceutical and medical areas with a customer base of: Miles Laboratories, Eli Lilly and Company, and Zeneca Pharmaceutical. AI Ware has received many awards for leading the industry in delivering computational intelligence solutions, including the R&D Magazine "Elite 100 Award" in 1994, and the Emerging Technology Award in 1995. In 1997, AI Ware was purchased by Computer Associates International, Inc., the world leader in mission-critical business software.
COTR – Jim Kiraly

Continuum Dynamics, Inc.

Computational Method for Aeroelastic Problems in Turbomachinery
Ewing, NJ

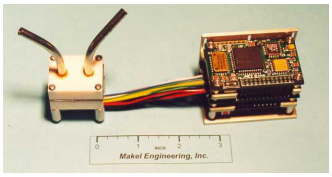


This project received $475K from New Jersey pharmaceutical companies for adapting the software for inhaler design to deliver medication. They also adopted software to analyze unsteady transport of vapor/liquid mixtures into complex internal flow geometrics.

Future applications for quality of life include sonic boom penetration studies in coastal waters for environmental impact of marine life.
COTR – John Lucero

Makel Engineering

Robust Exhaust Gas Sensing System Using Advanced Thin Film Chemical Sensors
Chico, CA



This project will benefit quality of life improvement with their low cost, miniature, MEMS based chemical sensor system for monitoring key exhaust species (oxides of nitrogen-NO_X, carbon monoxide-CO, and oxygen-O_2). Makel Engineering has entered into a joint development agreement with a major Ohio based fuel products original

equipment manufacturer (OEM) for application to exhaust measurements in reciprocating engines. They are presently working with the EPA & DOE on NO_X measurements in diesel engines. A potential future application of this project would be indoor air quality monitoring in buildings and vehicles.
COTR – Gus Fralick

Maverick Corporation

Safe Polyimides for Low-Cost Processing of High-Temperature Composites
Cincinnati, OH

This project is a family of cost competitive, high-temperature polyimide resins that are void of toxic compounds therefore, an improvement to the quality of life. The company received $500K from the Ohio Technology Action Fund to commercialize the technology for high temperature Resin Transfer Molding. NASA Glenn contributed $50K in follow-up funding along with $125K contributed by GE Aircraft Engines, Air Force, and BF Goodrich.
COTR – Mike Meador

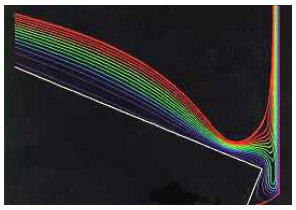
Microwave Monolithics, Inc.

High Efficiency, Low Cost Monolithic RF Module for SARSAT Distress Beacons
Simi Valley, CA

This project developed miniature, ultra high efficiency GaAs MMIC components for Search and Rescue Satellite Aided Tracker (SARSAT) Distress Beacons. Microwave Monolithics also developed miniature Personal Locator Beacons (PLBs). They invested $1.2M and developed a complete MicroPLB SARSAT Beacon. The MicroPLB is a vital safety device for both military and civilian government personnel providing rapid worldwide notification and location information in case of emergency.
COTR – Robert Kerczewski

Nektonics

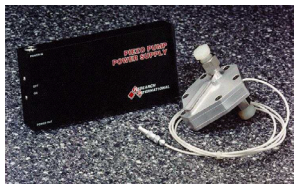
NEKTON: Tool for Coating Process Simulations
Cambridge, MA



This project has been used in designing and developing the first continuous glucose monitor. The monitor measures glucose levels through skin contact, eliminates the need for diabetic patients to prick their finger for samples. Nekton can be used to model coatings in such diverse industries as paper, magnetic media, film, and adhesives. This software was used in the Surface Tension Division Convection Experiment (STDCE), a low gravity fluid physics experiment flown on STS-50, June 1992 and STS-73, October 1995. Published in Spinoff 98.
COTR – Bruce Rosenthal

Research International

Solid State Micromachined Pump
Woodinville, WA

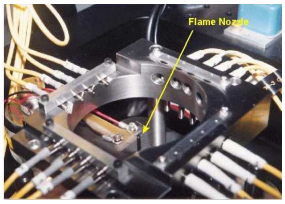


This technology has come to fruition and is being licensed to a Japanese company for use in food safety. Other commercial applications include the detection of toxins and pollutants in coal mines circulating heat transfer fluids, and monitoring fire and gas hazards aboard naval warships, as well as an early warning smoke detector for industrial applications. Research International has incorporated the

micromachined, no-moving parts pump into a four-channel, solid state fluorometer. A patent has been issued for MANTIS™, a tightly packaged, portable fully-automated immunoassay system for the detection of toxins and pollutants. A patent has also been issued for the manual immunoassay system, Analyte 2000. The MANTIS™ integrates optics, electronics, and software into an all-in-one way to monitor the progress of immunological reactions. Research International's micromachining methods are being used for the construction of miniature fluidic devices for use in medical drug delivery. Medtronic (a world leader in medical technology) has the rights to invivo applications for intractable pain. The company has tripled in size; from 10 to 30 employees. This technology was published in Spinoff 98.
COTR – Eric Golliher

Southwest Sciences, Inc.

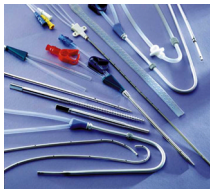
Near-Infrared Diode Laser Microgravity Combustion Diagnostic
Santa Fe, NM



The technology developed under this SBIR is used for perimeter monitoring of hazardous gases in refineries, for measurement of chemical process teams, and for detecting impurities in semiconductor manufacturing gases. This system is currently being used by NASA GRC to measure combustion gas concentrations in its drop tower facility. This technology was licensed to Ametek and another commercialization partner. Sales are over $2.3M and revenues from licensing are over $300K.
COTR – Paul Greenberg

Spire Corporation

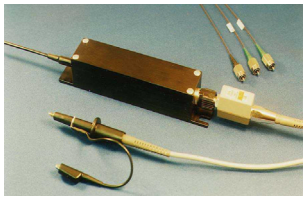
Oxidation Resistant Ti-6Al-4V-SiC Composite Materials by Ion-Beam Processing
Bedford, MA



This project has been very successful and has various medical applications. One primary biomedical application is silver-based antimicrobial coatings for reducing bacterial adhesion and proliferation on medical devices. St. Jude Medical is currently using the Antimicrobial Coatings on prosthetic mechanical heart valve suture rings. Spire currently processes over 10,000 medical device components annually resulting in several hundred thousand dollars in annual revenues. Broad medical device applications, i.e. various catheters and other implantable medical devices are being pursued with significant growth expected over the next few years.
COTR – James Smialek

Srico, Inc.

Integrated Optical Voltage Measurement System
Columbus, OH



The integrated optic voltage sensor technology developed under NASA SBIR Phase I & II programs now serves as the key platform for commercial products and advanced R&D projects in optical networking, test & measurement, and patient monitoring. Due to the unmatched benefits of this core sensing technology, their business is now in a very exciting growth phase.
COTR – Richard Patterson

The Technology Partnership

High Reliability Long-Term Lubricators
Grosse Ile, MI

This project validated a new use for shrink-polymers as implants for long-term drug-infusion pumps, and developed long-term time-dependent shrink-polymers for dispensing lubricants. Major drug companies are evaluating a universal drug-dispensing implant that uses viscoelastic technology. COTR – Robert Fusaro

Ultramet

Lightweight Structural Foams from Ceramic Materials
Pacoima, CA

This ceramic foam technology was spun off into the medical field as Hedrocel™ synthetic bone material. This project licensed medical foam technology to Implex, a manufacturer of musculoskeletal implants. Implex has invested $10M in production facilities and experimental trials. Ultramet formed a joint venture with Cytomatrix to develop biological cell growth medium using foam technology. COTR – Wayne Wong

AERONAUTICS

Small Business Innovation Research

Low Cost Electromagnetic De-Icer for Natural Laminar Flow Airfoils

Cirrus Design Corporation
Duluth, MN

INNOVATION

Electroexpulsive ice protection system that is compatible with natural laminar flow (NLF) wings and tails

ACCOMPLISHMENTS

- Developed an electroexpulsive ice protection system on natural laminar flow airfoils without compromising performance and efficiency
- Demonstrated performance with full-scale ice protection models in wind tunnel tests

Established baseline data from wind tunnel tests

COMMERCIALIZATION

- Cirrus Design has just completed certification of an innovative general aviation airplane, at a cost of $55M to private investors. Investors are providing additional funds to develop and certify a larger-engine version of the aircraft that will incorporate a NLF de-icing system
- The SBIR subcontractor continues to make improvements on the de-icing system at no expense to Cirrus Design
- The SBIR subcontractor has made sales of products that were a direct result of this SBIR

Cirrus SR20

GOVERNMENT/SCIENCE APPLICATIONS

- Important to NASA as part of the General Aviation Revitalization Program
- Important to the military for tactical unmanned aerial vehicles
- Important to the commercial utility of tactical unmanned aerial vehicles, which will be used for search and rescue operations, pipe line surveillance and forest fire surveillance

Glenn Research Center
General Aviation
3-035

1993 Phase II, NAS3-27646, 5/99
NASA Contact – Thomas Bond
Company Contact – Dean M. Vogel

Small Business Innovation Research

Computational Method for Aeroelastic Problems in Turbomachinery

Continuum Dynamics, Inc.
Ewing, NJ

INNOVATION

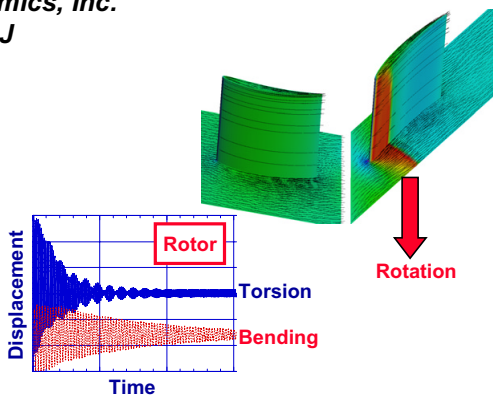
A state-of-the-art nonlinear aeroelastic code for cascades and rotors

ACCOMPLISHMENTS

- Developed software to predict turbomachinery flutter. The software was developed into 2-D and 3-D versions
- Adopted software to analyze unsteady transport of vapor/liquid mixtures into complex internal flow geometries
- Developed aeroelastic and structural modeling technologies for dynamic modeling of helicopter rotor systems

COMMERCIALIZATION

- Received $475,500 from New Jersey pharmaceutical companies for adapting the software for inhaler design to deliver medication
- Used the 3-D flow code in consulting with Washington Public Power Supply System. Received $96K
- The aeroelastic and structural modeling codes have generated $113K in licensing and $270K in contract research support. An additional $56K is expected



3D Aeroelastic Response for Rotor-Stator

GOVERNMENT/SCIENCE APPLICATIONS

- Code has application to rotorcraft design and has submarine application
- Applicable to sonic boom penetration studies in coastal waters for environmental impact on marine life
- Useful to higher order compact algorithm for studying acoustic problems

Glenn Research Center
Aeronautics
3-068

1988 & 1993 Phase II, NAS3-26064 & NAS3-27631, 6/01
NASA Contact – John M. Lucero
Company Contact – Alan Bilanin

Small
Business
Innovation
Research

Economical Hybrid Anti-Icing System

Cox & Company, Inc.
New York, NY

INNOVATION
An Ice Protection System suitable for roughness-sensitive airfoils that would typically be protected by anti-icing systems requiring greater energy

ACCOMPLISHMENTS

- Developed new methodology for lifting surface ice protection that combines electro-thermal anti-icing with Electro-Mechanical Expulsion Deicing System (EMEDS) to maintain leading edges clear of ice
- Received FAA certification on May 23, 2001
- Constitutes the first "new" certified ice protection system in more than forty years

Hybrid Anti-Icing System Tested at NASA Icing Research Tunnel by Cox and Raytheon Engineers

COMMERCIALIZATION

- In production for horizontal stabilizer on Raytheon Aircraft's new Premier I business jet
- More than 300 aircraft are on order and revenues are expected to be more than $10M over the next several years
- Further applications are being investigated and use on other airplanes is expected

GOVERNMENT/SCIENCE APPLICATIONS

- Helps satisfy the NASA goal of increasing aviation safety through the development of advanced ice protection system
- Useful on military aircraft of all sizes including advanced flight vehicles

Glenn Research Center
Aeronautics
3-071

1995 Phase II, NAS3-97031, 7/01
NASA Contact – Dean Miller/Andy Reehorst
Company Contact – Dr. Kamel Al-Khalil

Small
Business
Innovation
Research

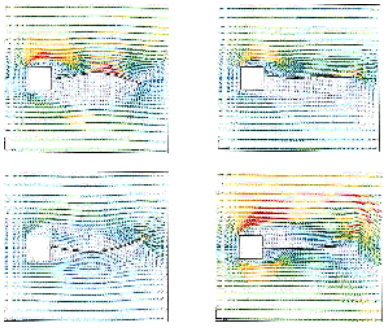
Fluid-Structure Interaction Using Unstructured Meshes

Fluent, Inc.
Lebanon, NH

INNOVATION
Unified treatment of fluid-structure interaction solving solid and fluid regions in one sweep

ACCOMPLISHMENTS

- Developed and tested robust and accurate schemes for computing flow on moving and deforming unstructured meshes
- Coupled a code for structural computation (both deformable bodies and rigid bodies with spring-mass-damper) to the code for fluid flow analysis



Deflection of Flexible Structure Behind Rigid Bluff Body

COMMERCIALIZATION

- Integrated the code developed under this SBIR as an important part of a general purpose CFD code
- Marketing and selling this general purpose CFD code under the name FIDAP
- Broad commercial application of FIDAP includes turbomachinery, automotive, chemical processing, material processing, biomedical, and offshore industries

GOVERNMENT/SCIENCE APPLICATIONS

- Useful to both NASA and the military in fluid-structure interaction problems in turbomachinery and in flexible and rotary wings

Glenn Research Center
Aeronautics
3-074

1993 Phase II, NAS3-27637, 12/01
NASA Contact – Nan-Suey Liu
Company Contact – Stefano S. Mereu

Small Business Innovation Research

Ice Detection Sensor System

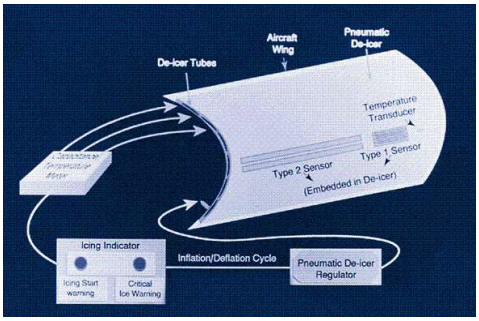
Innovative Dynamics, Inc.
Ithaca, NY

INNOVATION

An integral sensor/de-icer system will enable pilots to validate de-icer inflation and to determine if accreted ice has shed after system operation

ACCOMPLISHMENTS

- The IDI sensor system will be integrated into B.F. Goodrich pneumatic de-icers to achieve significant advances in early ice detection, bringing ice detection technology to the general aviation market at an affordable price



Automated ice protection system

COMMERCIALIZATION

- System has potential market value of $40-100M
- Market size of 20,000 to 50,000 general aviation aircraft
- Other applications include detection of ice on runways, highways, bridges, antennas and power lines
- B.F. Goodrich has acquired a license to the technology and patent rights for system

GOVERNMENT /SCIENCE APPLICATIONS

- Research supported by Icing Technology Branch within NASA Lewis Research Center
- Piper Malibu featured at September 94 icing technology open house

Glenn Research Center
Icing Technology

1985 & 1988 Phase II, NAS3-25200 &
NAS3-25966 SS-34, rev. 6/01
NASA Contact – Andrew Reehorst

Small Business Innovation Research

Self-Aligning Bearingless Planetary – SABP

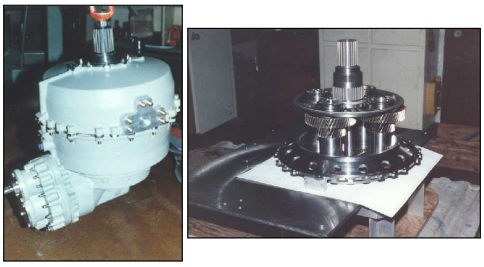
Transmission Technology, Inc.
Lincoln Park, NJ

INNOVATION

Transmission concept arranged so that all planets are internally load balanced and self aligning

ACCOMPLISHMENTS

- Designed, made, and successfully tested six prototype gear drives rated at 500HP with input speed up to 8,000 RPM and gear ratio's of 7 to 1, 16 to 1, and 20 to 1 per module
- Results of testing verified engineering analysis, demonstrated stability and viability of the gear drives, and showed performance improvements



Transmission assembly and it's installation in Helicopter Gear Box

COMMERCIALIZATION

- This gear drive arrangement can be used in all non-angle gear drive applications where speed change of 6 to 1 or higher is required
- As a result of a consulting arrangement with Transmission Technology, a commercial company developed and is using SABP in off-highway vehicles

GOVERNMENT/SCIENCE APPLICATIONS

- Numerous government applications can use SABP drives including various aircraft applications, main propulsion gearing for ship and submarines, and ship and submarines steering
- Can be used in various science and outer space projects that require a multitude of gear drives

Glenn Research Center
Aeropropulsion
3-043

1983 Phase II, NAS3-24539, rev. 3/02
NASA Contact – Dave G. Lewicki
Company Contact – Dezi J. Folenta

SUBSONIC SYSTEMS

Small Business Innovation Research

Dual-Spray Fuel Nozzle for Low Emissions Gas Turbine Combustors

CFD Research Corporation
Huntsville, AL

INNOVATION

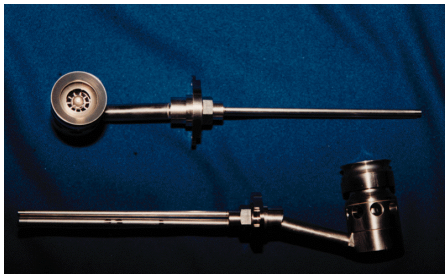
A fuel nozzle that provides high turndown fuel-air ratio and low emissions in small aircraft gas turbine engines

ACCOMPLISHMENTS

- Designed fuel nozzle using advanced CFD analysis
- Tested prototype nozzles at atmospheric pressure for lean blowout
- Fabricated and tested selected fuel nozzle in full annular combustor test at idle and simulated full power operating conditions
- Demonstrated lean blowout fuel-air ratio of 0.003 at idle conditions. This exceeds the current AST goal of 0.005

COMMERCIALIZATION

- Received over $175K in contracts from industry to study potential in AST combustors
- Selected as candidate by GE for 70% NOx reduction regional engine combustor program; fabrication and testing started in 1998. Received $500K in Phase III funding from GE
- If successfully demonstrated, nozzle has potential of being a production engine part. CFDRC will give the rights of the fuel nozzle to a fuel nozzle vendor in exchange for royalty fees



Prototype Fuel Nozzle

GOVERNMENT/SCIENCE APPLICATIONS

- Potential use in low emission aircraft gas turbine combustors
- Basis for further development of low NOx fuel-air mixers for land based gas turbine engines and other industrial combustion systems, e.g., burners, boilers, process heaters, etc.

Glenn Research Center
Advanced Subsonic Technology
3-004

1990 Phase II, NAS3-26616, rev. 9/99
NASA Contact – Chi-Ming Lee
Company Contact – Cliff Smith

Small Business Innovation Research

A Probability Density Function (PDF) Method for Turbulent Reacting Flow

CFD Research Corporation
Huntsville, AL

INNOVATION

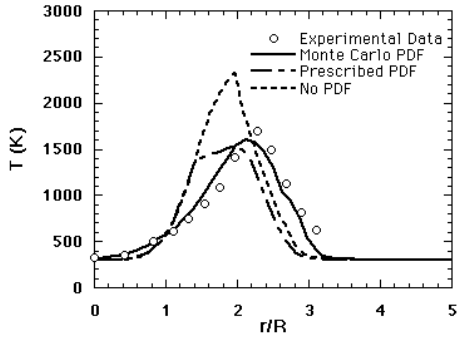
A Monte Carlo simulation technique for turbulent combustion and its viability for practical applications

ACCOMPLISHMENTS

- A Monte Carlo solution module for the composition PDF was developed to solve finite-rate chemical kinetics in turbulent flows
- The PDF module was coupled with a general purpose CFD code, CFD-ACE
- The PDF module was validated against experimental data for hydrogen and hydrocarbon combustion

COMMERCIALIZATION

- The PDF solution module has been incorporated into CFD-ACE and is being used by BMW and other selected clients on a trial basis
- The PDF solution module is also usable as an enhancement for other finite-volume CFD codes, such as CFD-FASTRAN
- The PDF solution technique is being improved and extended with additional NASA and CFDRC funding



Monte Carlo PDF Solution Agrees with Experimental Data (Piloted Jet Diffusion Flame) much Better than Solutions Using Simpler Models

GOVERNMENT/SCIENCE APPLICATIONS

- Prediction of emissions in turbulent combustion, especially automotive and aircraft engines and stationary power sources

Glenn Research Center
Advanced Subsonic Technology
3-003

1990 Phase II, NAS3-26608, 3/98
NASA Contact - Karl Owen
Company Contact - Dr. Andy Leonard

Small Business Innovation Research

Unstructured Density Based CFD Methodology for Gas Turbine Combustor Applications

CFD Research Corporation
Huntsville, Alabama

INNOVATION

A new methodology for efficient generation of large high-quality tetrahedral and prismatic meshes for CFD gas turbine combustor and other applications

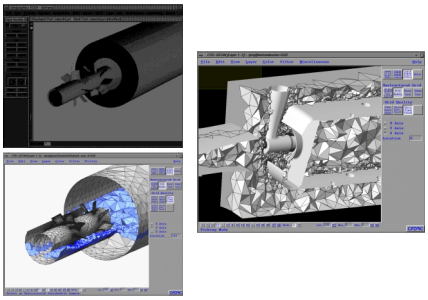
ACCOMPLISHMENTS

Developed software package CFD-GEOM with:

- Automatic curvature based unstructured grid generation on trimmed-NURBS geometry models
- Interactive assignment of boundary and volume conditions, directly on the geometry, configurable for various flow solvers
- Tetrahedral grid mesher for large grids (100K-300K cells per minute) based on Delauney and Advancing Front techniques
- Prismatic grid mesher for resolution of boundary layers based on Advancing Layers Method
- Direct interface to commercial CAD systems

COMMERCIALIZATION

- CFD-GEOM is being marketed as a stand-alone product for structured and unstructured grids, as well as in conjunction with CFDRC flow solvers
- Installed at more than 250 organizations worldwide for a variety of CFD grid applications. The average license fee is ~$5K



CFD-GEOM, with a direct link to UniGraphics, accepts true CAD data without IGES translation and generates complete unstructured grid systems with minimal user input

GOVERNMENT/SCIENCE APPLICATIONS

- Standard grid generation software for the National Combustor Code (NCC) computational framework
- Several Phase III extensions by NASA and CFDRC with NASA contributing $375K

Glenn Research Center
Advanced Subsonics Technology
3-006

1993 Phase II, NAS3-27632, 3/98
NASA Contact - Nan-Suey Liu
Company Contact - Dr. Vincent Harrand

MATERIALS

Small
Business
Innovation
Research

Durable Interface Coatings for Ceramic Matrix Composites

Advanced Ceramics Corp. (ACC)
Lakewood, OH

INNOVATION

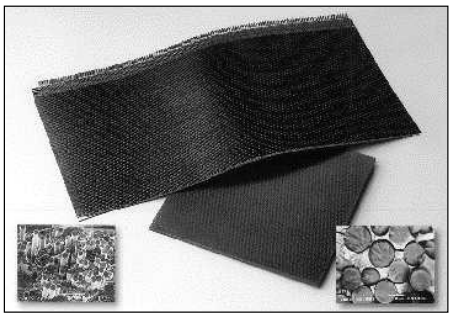
An interface coating that protects fiber-reinforced ceramic composites from moisture and oxidation at high temperatures

ACCOMPLISHMENTS

- Developed a family of high temperature and doped boron nitride coatings that offer orders of magnitude improvement in interface durability for SiC/SiC composites
- Demonstrated that fibers in woven fabrics can be coated as uniformly as fibers in tows

COMMERCIALIZATION

- Firm supplies durable interface coatings on fiber tows from a new scaled-up facility
- Sales of $100K to Fiber Reinforced Ceramic Matrix Composites (FRCMC) developers in 1996, with 1997 sales estimated at $300K
- Three new jobs were created



Digitized Images of Composites and Cloth

GOVERNMENT/SCIENCE APPLICATIONS

- Major impact on the Enabling Propulsion Materials Program of High Speed Research showed that the new interface coatings are more than 1,000 times more durable than the state-of-the-art
- Applicable to national programs aimed at ceramic composites development for military and terrestrial application
- Durability of interface coatings has been proven in glass, SiC, and Blackglas™ matrices

Glenn Research Center
Materials

1993 Phase II, NAS3-27690, SS-174, 8/97
NASA Contacts - Serene Farmer

Small
Business
Innovation
Research

Single Crystal Oxide Fibers: EFG Processing of Optical, Piezoelectric and Structural Materials

Advanced Crystal Products Corporation
Woburn, MA

INNOVATION

Computer controlled Edge Defined Film Fed Growth (EFG) Crystal Furnace-Puller for processing single crystal continuous fibers of various functional and structural oxides

ACCOMPLISHMENTS

- Designed & developed computer controlled EFG Furnace-Puller with data acquisition capability for single and multiple growth of oxide fibers
- Grew single crystal fibers of optical materials such as Lithium Niobate
- Grew single crystal fibers of piezoelectric materials such as Sodium Bismuth Titanate
- Grew single crystal (and eutectics) of Sapphire, YAG and other structural materials for use in composites
- Designed and built new hot zone capable of use in air or oxidizing atmosphere to 1600C to complement existing graphite 2300C inert atmosphere hot zones

COMMERCIALIZATION

- Sales to date – approximately $250K EFG system sold to MIT

EFG Furnace-Puller during growth of fibers

GOVERNMENT/SCIENCE APPLICATIONS

- NASA and the Department of Defense would have interest in using this technology to process research and prototype quantities of novel functional materials
- Foster-Miller Inc., Waltham, MA, has expressed interest in a larger system for their development of innovative ceramic composites and photonic materials

Glenn Research Center
Materials
3-065

1992 Phase II, NAS3-27306, 4/01
NASA Contact – Serene Farmer
Company Contact – Winfield Perry

Small Business Innovation Research

Novel Photorefractive Material ZnTe:V for Optical Processing

Brimrose Corporation of America
Baltimore, Maryland

INNOVATION

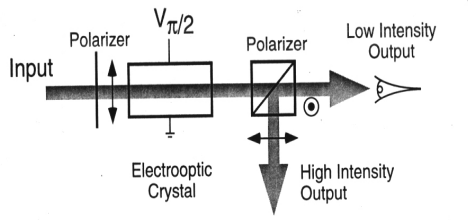
A new photorefractive material, ZnTe, that is optical limiting with real time holographic properties in the wavelength range of 0.63 to 1.6 μm

ACCOMPLISHMENTS

- Successfully demonstrated electro-optic power limiting (EOPL) and dynamic holography for wavelength of 0.63 to 1.6 μm
- Improved crystal growth techniques for related materials

COMMERCIALIZATION

- As result of this SBIR received follow-on funding of almost $1M from DoD for applications of ZnTe: $830K Air Force Phase I and II SBIR; $99K ARPA Phase I SBIR; and $66K for Air Force "White Paper" contract
- Used ZnTe in a novel photo-emf signal processor. Received $830K Army Phase I and II SBIR contracts for this spin-off
- Applied self-restraint in commercialization of an optical limiter because of the sensitive nature of DoD applications



Components of Electro-Optic Power Limiter

GOVERNMENT/SCIENCE APPLICATIONS

- A NASA sponsored research project with MetroLaser in Irvine, California used this material to demonstrate resonant holographic interferometric spectroscopy
- Air Force has expressed interest in continuing to fund further development of material for EOPL applications
- Company in England is interested in using this material for terahertz technology
- Received inquiries from France and Israel with regard to photorefractive and optical limiting materials

Glenn Research Center
Materials
3-058

1991 Phase II, NAS3-26983, 10/00
NASA Contact – Walter Duval
Company Contact – Sudhir Trivedi

Small Business Innovation Research

Oxidation Resistant Rocket Thrusters for High Performance Propellants

Ceramic Composites, Inc.
Millersville, MD

INNOVATION

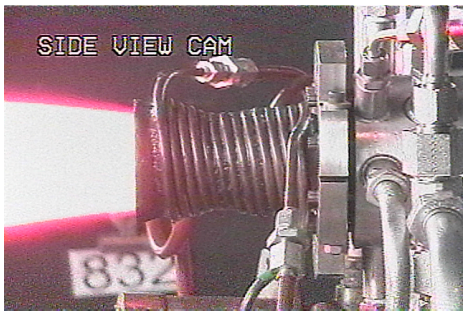
Chemical vapor infiltration process to fabricate low-cost, functionally graded ceramic matrix composites

ACCOMPLISHMENTS

- Developed rapid chemical vapor infiltration (CVI) process that leads to reduction in processing time and higher matrix densities. Fabrication times reduced by a factor of seven with up to a ten fold reduction in the fabrication cost
- Rapid CVI leads to directional matrix growth and to functional grading through the fiber preform. Lightweight $C_{(f)}$/C graded Ceramic Matrix Composites (CMCs) were fabricated which behave like Re or HfC, with density of less than 3g/cm^3
- Thrust cells tests with O_2 & H_2 propellants at operating conditions for 30 seconds showed no erosion at the throat
- Tested components in air at 4300F for 6 minutes. Excellent thermal stability was shown

COMMERCIALIZATION

- Patent applied for February 2000-Docket Number 1388
- Received $140K Phase III from MSFC
- Collaborating with commercial partners to develop components for liquid and solid Divert & Attitude Control System (DACS) and for flightweight, scramjet systems



Functionally graded CMC thrust cell during evaluation at NASA Glenn

GOVERNMENT/SCIENCE APPLICATIONS

- Hypersonic vehicle propulsion components are presently being evaluated under the DARPA HyFly Program
- This new family of lightweight materials will provide oxidation and erosion resistance for next generation NASA and DoD propulsion applications
- Divert and attitude control propulsion thrusters are presently being tested under BMDO and AF programs

Glenn Research Center
Marshall Space Flight Center
Materials
3-079

1993 Phase II, NAS3-27272, 1/02
NASA GRC Contact – Steve Schneider
NASA MSFC Contact – Pete Valentine
Company Contact – Mark Patterson

Small
Business
Innovation
Research

A Software Tool to Design Thermal Barrier Coatings

Deformation Control Technology, Inc.
Cleveland, OH

INNOVATION

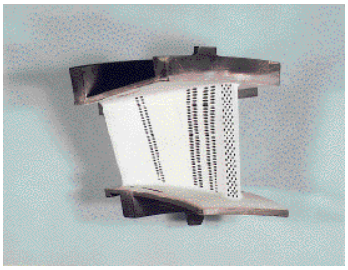
Software that enables design of ceramic coatings to enhance coating life and coated component life

ACCOMPLISHMENTS

- Successful incorporation of 5 main stress drivers into Thermal Barrier Coating (TBC) model, including oxidation
- First fundamental description of the role of oxidation in TBC failure
- Provided first basic statistical descriptors for quantifying interactive material property effects
- Provided basis for NASA TBC design innovation, patent pending

COMMERCIALIZATION

- In use to analyze test results and design TBCs for electric power generation turbine applications
- Commercial contract in excess of $10K was initiated prior to completion of Phase II work
- Strong commercial interest in future analysis based on the success of an exploratory contract
- This SBIR project resulted in an increase in employment, from 2 to 3 employees



Coated Aircraft Gas Turbine Stator Vane

GOVERNMENT/SCIENCE APPLICATIONS

- Presently in use to define failure mechanisms in TBCs
- Continued use to reduce costly experimentation while developing new TBC concepts
- In support of NASA HITEMP and Hybrid-Hyperspeed programs

Glenn Research Center
Materials
3-002

1993 Phase II, NAS3-27539 3/98
NASA Contact - Bill Brindley
Company Contact - B. Lynn Ferguson CD-98-77105

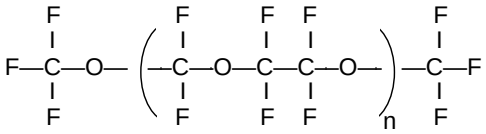
Small
Business
Innovation
Research

Perfluoropolyether Lubricating Fluids

Exfluor Research Corp.
Austin, TX

INNOVATION

New perfluoropolyether fluids for use at higher temperature (260°C) and in an oxygen environment, at lower costs than previous alternatives



Structure for perfluoropolyether

ACCOMPLISHMENTS

- Development of a series of fluids with good low temperature (-40°C) and high temperature (260°C) properties as well as oxygen stability

COMMERCIALIZATION

- Company has leveraged this technical knowledge to expand into specialty fluorocarbon chemical production for uses other than lubrication
- Technology licensed to the 3M Company
- Received $750K Air Force contract for optimizing a chemical structure for use in high performance jet engines
- Firm employment doubled as a result of SBIR activities

GOVERNMENT/SCIENCE APPLICATIONS

- Useful in the electronic industry and in Space Shuttle and high performance aircraft where lubricants are required that have a wide liquid range and a low volatility
- Technology can increase the operating temperature of jet engines, thus increasing engine efficiency

Glenn Research Center
Materials

1984 Phase 2, NAS3-24856, SS-114; 8/29/96
NASA Contact - William R. Jones

Small Business Innovation Research

Non-Toxic, Resin Transfer Molding (RTM) Processable, High Temperature Matrix Resin

Foster-Miller, Inc.
Waltham, MA

INNOVATION

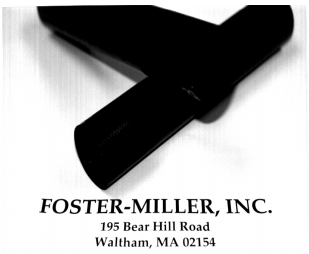
RTM processable, high temperature (T_g>600°F), low toxicity matrix resin system

ACCOMPLISHMENTS

- Developed matrix resin system by combining reactive diluents with the NASA developed AMB-21 polyimide resin
- Lowered the viscosity of the base resin significantly, decreased the amount of volatile by-products during cure, and increased cured T_g of AMB-21
- Successfully fabricated demonstration composite cylinders by RTM

COMMERCIALIZATION

- Estimated market for RTM processable PMR-15 substitute is $20-40 M/year
- Formed Pyrogonn l.l.c. for commercialization of this and related technologies
- Sample materials provided to McDonnell-Douglas, Dow-UT NASA, and GE Engines, for testing and evaluation



Composite Cylinders Manufactured via new RTM

GOVERNMENT/SCIENCE APPLICATIONS

- This resin system could replace PMR-15 as a high temperature organic matrix for carbon reinforced composites in aerospace propulsion systems and other high temperature structural applications where cost effective fabrication to near net-shape via RTM is desirable

Glenn Research Center
Materials
3-029

1994 Phase I NAS3- 27532, 12/98
1996 Phase II NAS3- 27818
NASA Contact - Mike Meador
Company Contact - Joseph Boyce

Small Business Innovation Research

Fiber Optic Systems for Composite Process Monitoring and Control

GEO-CENTERS, INC.
Newton Center, MA

INNOVATION

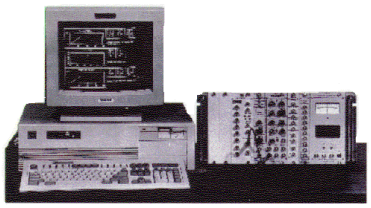
Fiber optic sensors for monitoring polymer matrix cure state, temperature, and pressure

ACCOMPLISHMENTS

- Developed fiber optic sensors for up to 400° C
- Developed methods to imbed fiber optic sensors into polymer matrix composites
- Methods of entrance and egress of optical fibers from autoclaves and molds to instrumentation were developed
- A simple instrument capable of monitoring 16 fiber optic sensors was developed

COMMERCIALIZATION

- Received commercial, DOE, and DOD funding totaling $250K (Phase III). DOE work was on resin transfer molded composites and DOD work was on monitoring the cure of molded explosives
- As a result of this SBIR, GEO-CENTERS further enhanced their business by purchasing a technical competitor, Micromet, Inc.
- Two new jobs were created



Polymer Matrix Cure Monitoring & Process Control System

GOVERNMENT/SCIENCE APPLICATIONS

- Important to NASA's Aeronautics High Temperature Materials (HITEMP), High Speed Civil Transport (HSCT), and Enabling Propulsion Materials (EPM) Programs
- Important to all military advance propulsion engine programs

Glenn Research Center
Instrumentation & Controls

1987 Phase II, NAS3-25817, SS-168, 9/97
NASA Contact - Kenneth Bowles

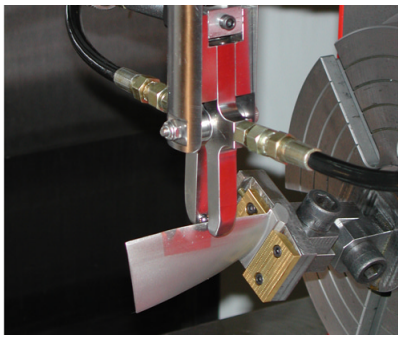
Small Business Innovation Research

Surface Enhancement for Improved Fatigue Life of Superalloys at Engine Temperatures

Lambda Research
Cincinnati, Ohio

INNOVATION

Low plasticity burnishing apparatus that produces deep layers of compressive surface residual stress



LPB Caliper Tool

ACCOMPLISHMENTS

- Developed and demonstrated low plasticity burnishing (LPB) as an affordable means of producing deep stable compression in metallic components
- Produced compressive layer essentially stable at engine operating temperatures by LPB
- LPB increases finite fatigue life by an order of magnitude, can double the endurance limit, and retard existing cracks

COMMERCIALIZATION

- Lambda Research created Surface Enhancement Technologies, LLC to license, market, and provide LPB
- Surface Enhancement Technologies employs 3 full time staff members
- NASA SBIR laid the ground work for a SBIR with NAVAIR

GOVERNMENT/SCIENCE APPLICATIONS

- Important to NASA, the Military, and DOE for aircraft and ground based turbines and aging aircraft. Because the compression doesn't relax at high temperatures, LPB is extremely useful; hence, this should save money for the military by extending aircraft life
- Demonstrated LPB on advanced disk superalloys, assisted by NASA Ultrasafe Propulsion Project

Glenn Research Center
Materials
3-073

1997 Phase II, NAS3-99116, rev. 11/01
NASA Contacts – Dr. Timothy Gabb & Jack Telesman
Company Contact – Kim Bellamy

Small Business Innovation Research

Novel Processing Technology for Electronically Conducting Polymers

Lynntech, Inc.
College Station, Texas

INNOVATION

A photopolymerized conducting polymer having multi-applications including printed circuit board fabrication and electrode materials for batteries and fuel cells

Fuel Cell Test Equipment

ACCOMPLISHMENTS

- The electrode materials for fuel cells led to the development of electrochemical test equipment which was further developed into a commercial product for the testing and evaluation of fuel cells

COMMERCIALIZATION

- Commercial sales of the fuel cell test equipment were initiated in August of 1999
- Lynntech's fuel cell test equipment has been sold to universities, national laboratories, and industrial fuel cell developers around the world
- First year sales of the fuel cell test equipment were in excess of $750,000

GOVERNMENT/SCIENCE APPLICATIONS

- As a successful product, Lynntech, Inc., continued the development of the fuel cell test equipment into a complete product line for fuel cell research and development
- Can be used in NASA's Reusable Launch Vehicle and Space Power programs

Glenn Research Center
Materials
3-059

1991 Phase II, NAS3-26998, 11/00
NASA Contact – Michael Meador
Company Contact – Dr. Oliver Murphy

Small Business Innovation Research

Safe Polyimides for Low-Cost Processing of High-Temperature Composites

Maverick Corporation
Cincinnati, OH

INNOVATION

A family of cost competitive, high-temperature polyimide resins that are void of toxic compounds

ACCOMPLISHMENTS

- Developed a family of low-toxicity polyimides that exhibit glass transition temperatures up to 335°C (635°F) and excellent thermal oxidative stability to 316°C (635°F) in aircraft engine environments
- These "novel" polyimides can be manufactured from fabric or braid using a variety of processes including: autoclave, solvent-assisted Resin Transfer Molding (RTM), and compression molding
- Complex parts produced included: LH_2 Test Duct for Reusable Launch Vehicles, High Pressure Cooling Tube, Center Vent Tube, and Stator Vane Bushings
- Thermal and mechanical properties were measured to be comparable to the current state-of-the-art resin system, PMR-15

COMMERCIALIZATION

- Recipient of a 2 year, $500K, Ohio Technology Action Fund grant to commercialize the technology for high-temperature RTM
- GRC contributing $50K for this effort. Other supporters include the Air Force, GE Aircraft Engines and BF Goodrich contributing a total of $125K
- Commercial batches of resin and prepreg have been produced and supplied to a variety of aerospace customers

4 ft. Aircraft Engine Cooling Tube Produced using the Solvent-assisted RTM Process.

GOVERNMENT/SCIENCE APPLICATIONS

- The technology should find widespread uses in aircraft engines and airframe applications
- These resins will reduce the cost and weight of aerospace structures; hence, useful to NASA's space program
- The military should find this technology useful in both aircraft and ground transportation

Glenn Research Center
Materials
3-069

1996 Phase II, NAS3-98024, 7/01
NASA Contact – Michael Meador
Company Contact – Eric Collins

Small Business Innovation Research

Processing of Metal Matrix Composites with Controlled Microstructures

Materials & Electrochemical Research (MER) Corporation
Tucson, AZ

INNOVATION

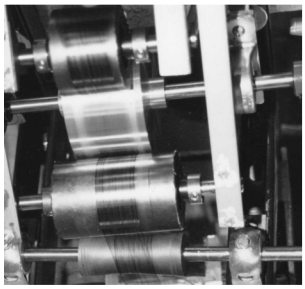
A semi-continuous hallow cathode magnetron system for coating small diameter fiber within multifilament fiber tow followed by matrix coating

ACCOMPLISHMENTS

- Developed fiber-spreading equipment
- Developed segmented hallow cathode magnetron coating system
- Developed interfacial coating for ceramic (Al_2O_3, SiC) and carbon fibers
- Developed matrix coating (copper, superalloys)
- Developed consolidation techniques, and characterized composite mechanical and thermal properties

COMMERCIALIZATION

- Produced variety of metal-coated fibers to various customers for evaluation
- Sales and internal development of more than $575K
- Prepared and presented business plan to several strategic alliances and venture capital groups to raise $5.5M for electronic heat sink applications



MER Automated Fiber Spreader

GOVERNMENT/SCIENCE APPLICATIONS

- High temperature composite materials for aerospace applications
- For use as a heat sink spreader for electronics
- For general use in heat management applications

Glenn Research Center
Materials
3-023

1993 Phase II, NAS3-27543, 5/99
NASA Contact - Susan Draper
Company Contact - Dr. R. O. Loutfy

Small
Business
Innovation
Research

Manufacturing of Refractory Metal Components

Metadyne, Inc.
Towanda, PA

INNOVATION

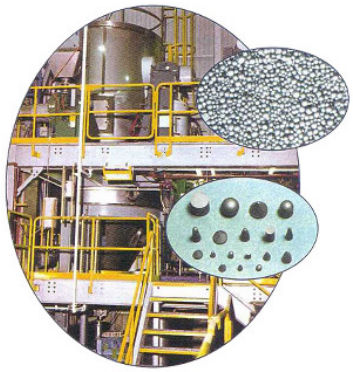
To develop powder metallurgy technology for Tungsten and Molybdenum alloys

ACCOMPLISHMENTS

- Manufacturing technology development of Tungsten, Molybdenum and their alloys
- Developed powder metallurgy technology for pressing and sintering of refractory metal components
- Developed powder metal manufacturing operation

COMMERCIALIZATION

- A successful business corporation with commercial sales - more than $25M (over $6M per year) with a significant amount resulting from this SBIR
- Providing over 35 jobs at its manufacturing plant. Many of these resulted from this SBIR
- Manufacture and sales of Tungsten and Molybdenum alloy components for mining, construction, electronic and defense applications
- Export markets resulted for these products



Tungsten and Molybdenum Alloy Components

GOVERNMENT/SCIENCE APPLICATIONS

- These high temperature and high performance alloys are in use for various defense and electronic applications

Glenn Research Center
Materials
3-044

1985 Phase II, NAS3-25149, 10/99
NASA Contact – Michael V. Nathal
Company Contact – Raman L. Daga

Small
Business
Innovation
Research

Pressure Infiltration Casting of Superalloy Composites

Metal Matrix Cast Composites, Inc.
Waltham, MA

INNOVATION

High temperature vacuum transfer of alloys for pressure infiltration of ceramic and carbon fiber preforms

ACCOMPLISHMENTS

- Successfully cast superalloy composites utilizing vacuum melting and transfer to mold vessel
- Developments were applied to the manufacture of copper and aluminum matrix composites for electronic thermal management materials

High Temperature Vacuum Transfer (APIC™) Facility

Boeing K-band Module Housings for Spaceway™ Phased Array Antenna

COMMERCIALIZATION

- $1.7M production facility started in January 01
- Formed a strategic alliance with IXION, Inc. for a two year supply agreement at predefined quantities and price for the microelectronic packaging field of application
- Owners investment, commercial leases and loans, supply agreement fees and reinvested profits amount to $2M
- Twenty four full time jobs as a result of the innovation

GOVERNMENT/SCIENCE APPLICATIONS

- Materials for Boeing Spaceway™ Modules are now being applied to a number of DOD satellite communication systems
- A wide range of electronic, microwave, and optical packaging applications are in various stages of production, prototype development, and advanced research
- Will be used for the Boeing Spaceway satellite communication system in 2002

Glenn Research Center
Materials
3-077

1993 Phase II, NAS3-27541, rev. 2/02
NASA Contact – Michael Nathal
Company Contact – J. Cornie

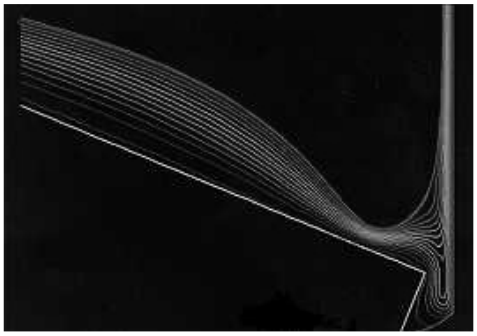
Small Business Innovation Research

NEKTON: Tool for Coating Process Simulations

Nektonics, Inc.
Cambridge, MA

INNOVATION

Powerful simulation software for the modeling and analysis of a wide range of coating flows



Slide coating Analysis with NEKTON

ACCOMPLISHMENTS

- Produced a fluid dynamics computer modeling tool for simulation and analysis of a wide range of coating flows

COMMERCIALIZATION

- Commercial version brought to market by Fluent, Inc. as NEKTON 2
- Product introduced computational fluid dynamics to the coatings industry
- Developed annual revenue of $400K
- Superseded in 1996 by NEKTON 3.0 for industrial customers
- NEKTON 2 continues to be used in universities

GOVERNMENT/SCIENCE APPLICATIONS

- Software was used in the Surface Tension Driven Convection Experiment (STDCE), a low gravity fluid physics experiment flown on STS-50, June 1992 and STS-73, October 1995
- NEKTON can be used to model coatings in such diverse industries as paper, magnetic media, film and adhesives

Glenn Research Center
Materials

1990 Phase 2; NAS3-26725, SS-132; 5/12/97
NASA Contact - Bruce Rosenthal

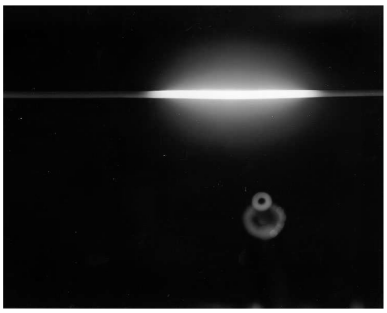
Small Business Innovation Research

Innovative Laser Furnace

Penn Laboratories, Inc.
Anniston, AL

INNOVATION

A high temperature laser furnace for mechanical testing of ceramic fibers



Laser Fiber Test Sample

ACCOMPLISHMENTS

- Furnace incorporates room temperature mounting grips and a uniform hot zone with relatively sharp boundaries and controllable length
- Furnace capable of selective heating of single crystal fibers at temperatures of up to 3000^{o}C
- Capable of implementing tensile tests under thermal load conditions

COMMERCIALIZATION

- Firm received a Phase III contract for $163K from Metal Samples Co., Inc.

GOVERNMENT/SCIENCE APPLICATIONS

- Being applied to NASA's Advanced High Temperature Materials Program (HITEMP), in Enabling Propulsion Materials (EPM) Program, and part of the High Speed Research Program (HSR)
- Useful to Navy programs such as High Temperature Phase Diagram studies
- Furnace used at NASA Lewis Research Center for ceramic fiber research

Glenn Research Center
Materials

1990 Phase 2, NAS3-26663, SS-133, 3/21/97
NASA Contact - Ali Sayer

Small Business Innovation Research

Laser Float-Zone Process Improvements

Penn Laboratories, Inc.
Anniston, AL

INNOVATION

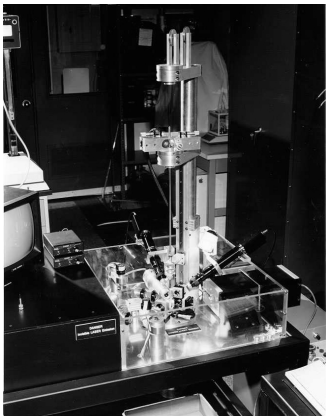
Laser heated Melt Modulation™ technique for ceramic fiber growth

ACCOMPLISHMENTS

- A furnace was designed and constructed to evaluate laser heated ceramic fiber growth
- Multi-Wave™ pyrometer was developed for use in this furnace
- Pyrometer measures temperatures up to 3000^{o}C in an area as small as 75 microns, at a distance of 30 mm from the target, with field of view approximately 2,000 microns

COMMERCIALIZATION

- The Multi-Wave™ pyrometer, Multi-Wave™ HT-1C, is currently commercially available
- NASA Lewis purchased two Multi-Wave™ pyrometers for fiber research at a total cost of $30K



Laser Heated Fiber Growth Furnace

GOVERNMENT/SCIENCE APPLICATIONS

- Technology applied in NASA's High Temperature Engine Material Program(HITEMP)
- USAF Office of Scientific Research is applying the technology at the Wright Laboratory Materials Directorate in the Edge-Defined Film-fed Growth (EFG) project

Glenn Research Center
Materials

1988 Phase 2, NAS3-25944, SS-159, 3/24/97
NASA Contact - Ali Sayer

Small Business Innovation Research

Oxidation Resistant Ti-6Al-4V-SiC Composite Materials by Ion-Beam Processing

Spire Corporation
Bedford, MA

INNOVATION

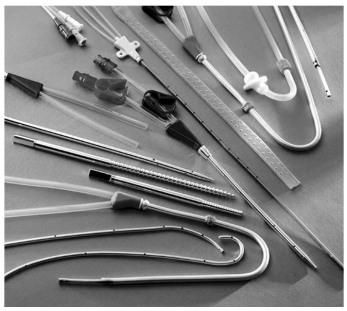
Developed silver-based antimicrobial coatings for reducing bacterial adhesion and proliferation on medical devices.

ACCOMPLISHMENTS

- Demonstrated significant reduction in bacterial growth and colonization on treated medical device surfaces

COMMERCIALIZATION

- Foundations of the antimicrobial coating technology were developed under NIH and NSF grants and contracts. Continued work with NIH includes development of silver-based antimicrobial coatings for additional medical device applications.
- Earlier, the NASA SBIR Phase I contract contributed to the establishment of Spire's ion beam assisted deposition (IBAD) processing capabilities, upon which the antimicrobial coating technology is based
- Spire currently processes over ten thousand medical device components annually, resulting in several hundred thousand dollars in annual revenues
- Broad medical device applications, i.e. various catheters and other implantable medical devices, are being pursued with significant growth expected over the next few years
- Increase in employment of 4 people



9805-78A

Antimicrobial IBAD silver coated medical device components

GOVERNMENT/SCIENCE APPLICATIONS

- Potential uses in limiting device-related infection for military applications/personnel
- St. Jude Medical is currently using the Antimicrobial Coatings on prosthetic mechanical heart valve suture rings

Glenn Research Center
Materials
3-011

1987 Phase I, NAS3-25326, 6/98
NASA Contact - James Smialek
Company Contact - Ron Scharlack

Small
Business
Innovation
Research

Perfluoropolyalkylether Fluid as High Temperature Lubricant

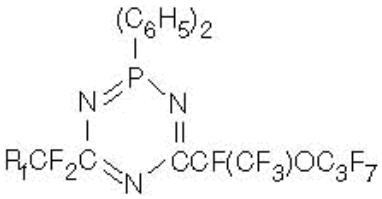
Ultrasystems, Inc.
Irvine, CA

INNOVATION

Perfluoropolyalkylether fluids for lubrication capable of performance between -50 and 316°C in the presence of metals in oxidizing environments

ACCOMPLISHMENTS

- End-capping perfluoropolyalkylether chains with phospha-s-triazine rings has produced fluid stability up to 316°C
- The new fluid also reduces degradation in the presence of metals or under boundary lubrication and resists metal corrosion
- Evaluated a series of perfluoropolyalkylether fluids and greases and developed performance guidelines



Structure for Perfluoropolyalkylether (Phospha-triazine capped)

COMMERCIALIZATION

- Phase II report is used nationwide as guidance data for lubricating greases and fluids, with company researchers recognized as technology leaders
- Commercial applications include aircraft instrument bearing lubricant, computer memory disc surface lubricant, vacuum pump oils and base stock for specialty greases and antiseize compounds
- Ultrasystems was absorbed by Lubricating Specialties Co., Technology Products Division
- Received two Air Force contracts - one contract is worth $600K

GOVERNMENT/SCIENCE APPLICATIONS

- NASA applications include potential replacement of fluids currently used in space instrumentation as well as advanced aircraft lubrication
- Used in satellite guidance systems including Geostationery Operational Environmental Satellites (GOES); Television Infrared Observation Satellite (TIROS); Earth Radiation Budget Satellite (ERBE); LANDSAT series

Glenn Research Center
Materials

1983 Phase II, NAS3-24632, SS-115, 7/96
NASA Contact - William R. Jones

POWER AND ON-BOARD PROPULSION

Small
Business
Innovation
Research

STABLCOR Printed Circuit Boards

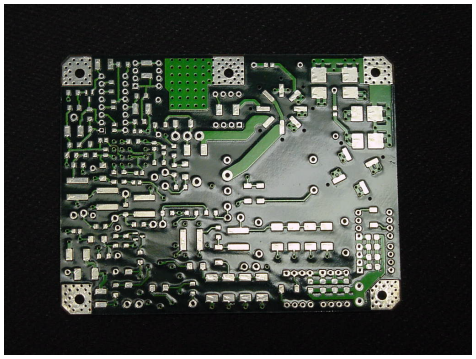
Applied Material Technologies, Inc.
Santa Ana, CA

INNOVATION

Printed circuit board with a high conductivity and low thermal expansion core material

ACCOMPLISHMENTS

- Developed a printed circuit board that improves thermal heat dissipation and reduces thermal expansion mismatch between the board and the integrated circuit components
- Prototype units manufactured and qualification tested by Boeing Commercial Space Systems
- Manufacturing process developed and transitioned to production at a commercial manufacturing facility



Printed Circuit Board with New Core Material

COMMERCIALIZATION

- AMT has sold an exclusive license to SDC Circuits for cash plus revenues related to future sales
- $50K authorized and spent to conduct qualification life tests
- A strategic alliance between AMT, SDC Circuits and Ramtek, Inc. has been formed for servicing the memory and computer markets
- SDC Circuits has spent approximately $1M on manufacturing development of the production process
- Discussions with venture firms indicate a potential for $20M investment
- Primary commercial interest to date is from the high data storage memory markets and from server markets

GOVERNMENT/SCIENCE APPLICATIONS

- Interest from government has been for space and military systems
- This technology is useful for other science applications

Glenn Research Center
Space Power
3-076

1995 Phase II, NAS3-97040, 11/01
NASA Contact – Ken Mellott
Company Contact – William E. Davis

Small
Business
Innovation
Research

Alternator and Suspension for Free Piston Stirling Engines

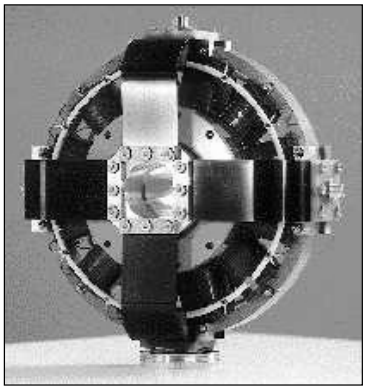
Clever Fellows Innovation Consortium, Inc.
Troy, NY

INNOVATION

A compact alternator/motor with reduced size and mass and high efficiency that has unlimited service life

ACCOMPLISHMENTS

- Produced a commercial prototype solar power generator using STAR™ alternator/motor
- Constructed and demonstrated a working model for a cryogenic cooler with STAR™ alternator/motor
- Demonstrated the STAR™ alternator/motor for uses as a motor in a gas or air compressor



High-efficiency affordable reciprocating motor

COMMERCIALIZATION

- Licensed Cummins to build and market a solar powered generator, this project recently sold to Kombassan, a Turkish firm
- STAR™ alternator/motor units sold around the world, $900K in sales in 1995
- Contract with New York state for $395K to develop gas fired generator
- Sold multiple licenses for cryogenic refrigeration services utilizing STAR™ based cryogenic coolers

GOVERNMENT/SCIENCE APPLICATIONS

- Solar dynamic power for future use in Space Station
- STAR™ motor could be used on cryogenic coolers in test programs throughout NASA
- Combined with Thermoacoustic engine to produce ultra-reliable generator for micro co-generation products

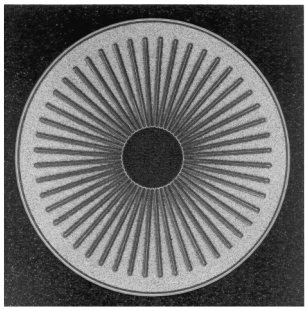
Glenn Research Center
Space Power Technology

1990 Phase 2; NAS3-26603, SS-44; 8/97
NASA Contact - Lanny Thieme

Small Business Innovation Research

High Temperature, Silicon Carbide, Power Thyristor

Cree Research, Inc.
Durham, NC



Micrograph of a 10 Amp 4H-SiC Power Thyristor

INNOVATION

A process for producing high performance power Thyristors in Silicon Carbide (SiC) capable of operating at 350°C

ACCOMPLISHMENTS

- Demonstrated the first power thyristor in SiC
- Fabricated high-performance Thyristors in SiC that passed 1000 hour test at 350°C
- Operated SiC thyristors to temperatures as high as 500°C
- Achieved world record SiC power level of 4.2 kilowatts

COMMERCIALIZATION

- Increased SiC material and device sales by >$3.8M
- Created 14 new jobs and saved existing jobs
- Initiated tremendous worldwide interest in the area of SiC power semiconductors, resulting in multi-$M programs in SiC MOSFETs for government and commercial labs
- Total market potential for SiC Power Thyristors would be >$200M

GOVERNMENT/SCIENCE APPLICATIONS

- Will be used in military electric vehicles, i.e., electric tanks, more-electric airplane, and shipboard power distribution
- Applicable for high temperature power conditioning in spacecraft and will reduce weight and size of spacecraft
- Can be used to replace Silicon power devices in power circuits for large electric vehicles and locomotives, and for solid state power distribution of electricity for utilities
- SiC Thyristors offer much lower switching losses than silicon devices in theses applications. Potential power savings of >$1B/yr are possible

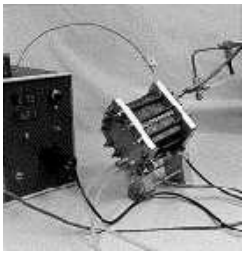
Glenn Research Center
Space Power
3-022

1991 Phase II, NAS3-26927 , 9/98
NASA Contact - Gene Schwarze
Company Contact - John Palmour

Small Business Innovation Research

High Efficiency Proton Exchange Membrane Fuel Cell

ElectroChem, Inc.
Woburn, MA



PEM Fuel Cell

INNOVATION

Self humidified, high reactant utilization fuel cell stack for operation with H_2/O_2 reactants

ACCOMPLISHMENTS

- Development of an “off-the-shelf” commercial fuel cell as part of ElectroChem’s product line of research supplies and instruments to the fuel cell community
- ElectroChem, Inc. has made advancements in their design of fuel cell stacks. As a result, they will be able to manufacture larger fuel cell stacks (500 cm^2) which will deliver up to 2kW of power in addition to their smaller fuel cell stacks (50 cm^2)
- The ElectroChem, Inc. Proton Exchange Membrane (PEM) fuel cell can operate at high reactant utilization, does not need external reactant humidification, and can operate at atmospheric pressure

COMMERCIALIZATION

- System integration work proceeding for other applications such as back-up power systems, recreational vehicles, and stand-alone regenerative power systems
- Can be used in rural electrification and in underwater vehicles

GOVERNMENT/SCIENCE APPLICATIONS

- Study of fuel cell operation in upper atmospheric scientific balloon for NASA Wallops’ Balloon Program
- Could be used in remote power applications for the defense industry
- Commercial sales of $53K for several units to NASA for use in atmospheric studies as part of a SBIR Phase III

Glenn Research Center
Space Power Technology

1992 Phase II, NAS3-27242, SS-180, 11/97
NASA Contact - Dr. Patricia Loyselle

Small Business Innovation Research

High Temperature Oxidation-Barrier Coatings for Refractory Metals

Electroformed Nickel, Inc.
Huntsville, AL

INNOVATION

Electrodeposited iridium as a high density coating to prevent oxidation of the refractory substrate and insure long life in severe thermal environments

ACCOMPLISHMENTS

- Using the iridium coating over rhenium substrates prototype radiation cooled attitude control thrust engines, such as would be employed in satellites for maneuvering, accumulated hot firing cycle life to 14 hours at 3400ºF, has been demonstrated by NASA Lewis Research Center

COMMERCIALIZATION

- Sales to date have totaled $107K
- A strategic alliance has been formed between Rhenium Alloys Inc. (to supply rhenium chambers by an improved powder metallurgy process), Electroformed Nickel, Inc. (to provide a high integrity iridium oxidation barrier coating) and TRW (to design, qualify and market the product)
- A full time engineer has been added to the professional staff to manage the new coating process
- TRW anticipates a widespread use of this process in a product aimed at world-wide commercial satellite customers

Iridium plated 100Lb Rhenium Thrust Chamber

GOVERNMENT/SCIENCE APPLICATIONS

- USAF Phillips Laboratories has show an interest in this coating process for rocket nozzle inserts to extend the life and range of missile devices. Such an insert was fabricated and successfully fired by Edwards AFB
- Interest in these coatings has also been expressed by Lawrence Livermore National Laboratories

Glenn Research Center
Space Power
3-018

1989 Phase II, NAS3-26256, 9/98
NASA Contact - Robert Jankovsky
Company Contact - Glen Malone

Small Business Innovation Research

Composite Regenerator for Stirling Engine

Energy Science Labs, Inc.
San Diego, CA

INNOVATION

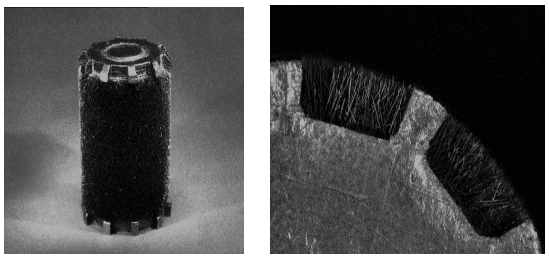
A process for carbon fiber flocking on a carbon substrate to produce high radial and low axial thermal conductivity at high temperatures (1000ºC)

ACCOMPLISHMENTS

- Development of a carbon-carbon composite matrix Stirling engine regenerator providing high temperature capability and high radial, low axial conduction
- Developed a carbon fiber flocking process to fabricate the composite matrix regenerator

COMMERCIALIZATION

- Sales of $1.8M in 1995, half of the sales were generated by carbon fiber flocking
- Expansion of manufacturing facility by over 40% and increase in staffing by 33%
- High conductance thermal interface gaskets for use in aerospace thermal management and electronics packaging
- Transverse reinforcements for delamination resistance in composite materials used in primary aircraft structures



Example of Flocked Carbon Fiber

GOVERNMENT/SCIENCE APPLICATIONS

- Compliant heat transfer interface and composite phase change material for advanced refrigerators/freezers for Space Station and Space Shuttle
- Black surfaces for stray light suppression in spacecraft instruments

Glenn Research Center
Materials

1989 Phase 2, NAS3-26249, SS-41, 4/2/96
NASA Contact - Diane Chapman

Small Business Innovation Research

Fresnel Lens Photovoltaic Concentrator Array

ENTECH, Inc.
Keller, TX

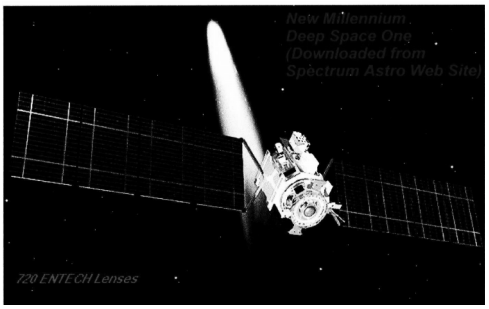
INNOVATION

Domed/Arched refractive concentrator system providing higher efficiency at lower weight and cost

- Developed both Point-Focus Mini-Dome lens and Line-Focus Cylindrical Lens Arrays for space power application
- SCARLET array (derived from line-focus lens concept) provides spacecraft power at one-half to one-third the cost of current arrays

COMMERCIALIZATION

- Over $1 Million in Space Lens sales to date to Boeing, AEC-Able Engineering, and others.
- More than 20 new jobs were created at these companies
- Approximately $10 Million in space array sales to date by ENTECH's customers
- SCARLET arrays now being commercialized/marketed by AEC-Able Engineering Team
- $350K in Phase III funding from NASA Lewis



SCARLET Space Array

GOVERNMENT/SCIENCE APPLICATIONS

- NASA/USAF/Boeing PASP+ (Photovoltaic Array Space Power plus Diagnostics) experiment flown in 1994 - first successful demonstration of ENTECH lens concept in space
- BMDO/NASA Lewis SCARLET 1 Array successfully built and space qualified for METEOR satellite
- 2,600 watt SCARLET 2 array to provide power for JPL's New Millennium Deep Space One Mission launch in 1998

Glenn Research Center
Space Power Technology

1985 Phase II; NAS3-25192, 12/97
NASA Contact - Michael Piszczor

Small Business Innovation Research

Lightweight Graphite/Aluminum (Gr/Al) Space Radiators for Thermal Management

Foster-Miller, Inc.
Waltham, MA

INNOVATION

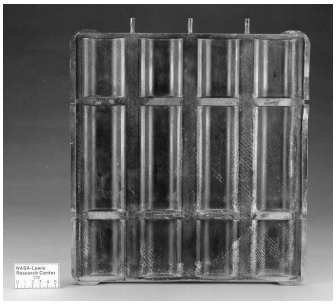
Lightweight metal matrix composites (MMCs) with superior heat removal for structural radiators and thermal management of electronics

ACCOMPLISHMENTS

- Designed and produced Gr/Al radiator panel with built-in heat-pipe housing
- Demonstrated substantial weight and thermal performance over baseline radiator components. Electronic substrate provided 10% reduction in weight and 50% improvement in performance. Radiators provide a 50% improvement in weight and/or performance
- Designed, produced and demonstrated substantial benefits in terms of heat removal and weight for Gr/Al as a substrate for electronics

COMMERCIALIZATION

- Commercial sales for MMC substrates for electronics will be over $40K for 1997
- Two new jobs were created
- Army funded a program for $550K to place inserts in MMC components



Radiator Panel from MMC

GOVERNMENT/SCIENCE APPLICATIONS

- Gr/Al MMCs have application in dimensionally stable spacecraft structure and optical platforms, and they have thermal management application in gas turbines and rocket engines.
- Use of these MMCs as a substrate in electronic products will reduce cost and improve reliability of radars, satellites, and other electronics intensive systems
- Samples of MMC electronics substrates are being supplied to government prime contractors for evaluation. Keen interest has also been expressed by aerospace contractors in MMC radiators.

Glenn Research Center
Space Power Technology

1992 Phase II, NAS3-27385, 11/97
NASA Contact - Karl Baker

Small Business Innovation Research

Application of GaS in the Passivation of GaAs and Related Alloys

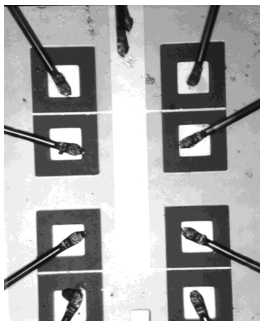
GALLIA, Inc.
Weston, MA

INNOVATION

A surface coating of Gallium Sulfide (GaS) for Gallium Arsenide (GaAs) and other III-V solar cells

ACCOMPLISHMENTS

- Discovered a stable cubic phase of GaS that could passivate the surface of GaAs solar cells, other optoelectronic and microelectronic devices
- Developed techniques for determining surface passivation
- Developed new passivation technology



4 Metal-Semiconductor Field-effect Transistors (MESFETS) with GaS Passivation between the GaAs Semiconductor and the Gate Metal

COMMERCIALIZATION

- **This passivation technology is used in all cell phones**
- TRI-QUINT, a manufacturer of microelectronic and optoelectronic devices, purchased GALLIA, Inc. and the passivation technology. The passivation technology was used to improve their GaAs discrete devices

GOVERNMENT/SCIENCE APPLICATIONS

- It is used or can be used on solar cells and other GaAs devices for many NASA missions
- NASA and the Military benefits by increases in “End of Life” efficiency and reliability with this technology

Glenn Research Center
Power Technology
3-072

1993 Phase II, NAS3-27552, 9/01
NASA Contact – Roshanak Hakimzadeh
Company Contact – Donald Caippenelli

Small Business Innovation Research

Novel Electrodes for Hydrogen/Bromine Battery

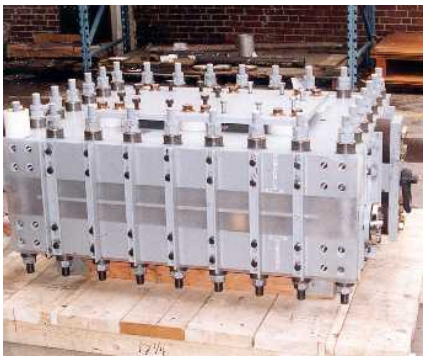
Giner, Inc.
Waltham, MA

INNOVATION

Efficient electrocatalysts and electrode structures for application in regenerative hydrogen-halogen fuel cell systems

ACCOMPLISHMENTS

- Developed electrode components for a unitized electrochemical cell that could operate in either a fuel cell or electrolyzer mode
- Fabricated complete regenerative hydrogen-bromine fuel cell system and subjected it to multiple charge/discharge cycles



Large Electrochemical Reactor

COMMERCIALIZATION

- Completed a contract ($662K) with a large chemical manufacturing company to design and fabricate a large HCl electrolyzer stack, a multi-cell unit, with each cell having an active area of $1M^2$
- Extended technology for possible use in regenerative H_2/O_2 fuel cells and large scale water electrolyzers

GOVERNMENT/SCIENCE APPLICATIONS

- Potential application as an electrochemical storage device for load-leveling applications
- Commercial interest for use in halogen acid electrolysis

Glenn Research Center
Space Power
3-041

1984 Phase II, NAS3-24878, 10/99
NASA Contact – Rick Baldwin
Company Contact – Dr. Anthony LaConti

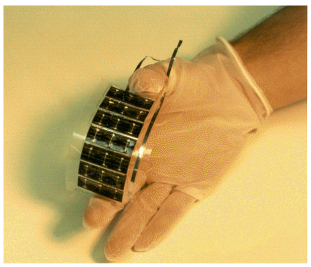
Small Business Innovation Research

Light-Weight Flexible Thin Film Solar Cells for Space Applications

International Solar Electric Technology
Inglewood, CA

INNOVATION

Light-weight, high power density thin film solar cells on flexible substrates



Flexible Copper-Indium-Diselenide Solar Cells

ACCOMPLISHMENTS

- Produced polycrystalline copper-indium-diselenide (CIS) solar cells on flexible metal foils
- Work led to an Air Force-supported project that resulted in the demonstration for the first time of CIS solar cells with over 1 kW/kg power density on polymeric substrates
- Received innovation award from NASA

COMMERCIALIZATION

- A joint experimental effort is in progress with a multinational company to produce the cells on a specific light weight substrate
- Received over $3M Advanced Technology Program contract for communications applications of these devices

GOVERNMENT/SCIENCE APPLICATIONS

- Very attractive for many NASA, commercial and military satellite power applications
- Useful for terrestrial applications where light weight and flexibility of solar cell is desired

Glenn Research Center
Space Power
3-027

1990 Phase II, NAS3-26615, 12/98
NASA Contact - Henry Curtis
Company Contact - Bulent Basol

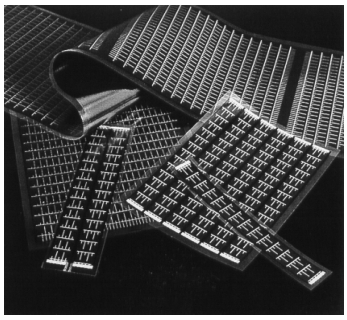
Small Business Innovation Research

Flexible, Lightweight, Amorphous, Silicon Solar Cells Tuned for Air Mass Zero (AMO) Spectrum

Iowa Thin Film Technologies, Inc.
Ames, IA

INNOVATION

Tandem amorphous silicon modules on a polyimide substrate



Flexible Amorphous Silicon Modules on a Polyimide Substrate

ACCOMPLISHMENTS

- Optical modeling to calculate thicknesses of device layers for maximum AMO solar spectrum absorption
- Deposition parameters for device layers optimized for performance of amorphous silicon solar cells in space
- Construction of a dedicated tandem amorphous silicon deposition machine

COMMERCIALIZATION

- Company sales as a result of SBIR were $200K and growing
- ITFT increased from a few employees to 12 full time and 8 part time employees
- Phase III monies totaled $4.7M from several government and private sources. The DOE National Renewable Energy Labs (NREL) is the largest government contract.
- Private investment provided the financing of a just completed production facility

GOVERNMENT/SCIENCE APPLICATIONS

- ITFT amorphous silicon modules for space applications are under evaluation at the NASA JPL
- ITFT modules are under evaluation at the NREL/DOE Laboratory for terrestrial applications
- Companies evaluating our material for space applications include Lockheed-Martin and TRW, which includes testing in space

Glenn Research Center
Space Power Technology

1989 Phase II, NAS3-26244, 10/97
NASA Contact - Dennis Flood

Small Business Innovation Research

30-Percent Efficient, Tandem Solar Cells for Line-Focus Photovoltaic Array

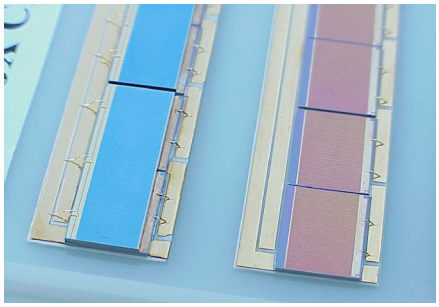
JX Crystals Inc.
Issaquah, WA

INNOVATION

High performance photovoltaic (PV) receiver for use with line-focus solar concentrator arrays for efficient generation of power in space

ACCOMPLISHMENTS

- Demonstrated PV receiver for a line-focus refractive concentrator using mechanical stacking of photovoltaic cells
- Fabricated gallium-antimonide (GaSb) photovoltaic solar cells which are applicable for space and terrestrial thermophotovoltaic (TPV) systems



Mechanically Stacked PV Cell Receiver Units (Right, GaSB cells without top cells — Left, final product)

COMMERCIALIZATION

- This SBIR served as a major stepping-stone in receiving a Ballistic Missile Defense Organization (BMDO) 1997 SBIR managed by GRC (Contract NAS3-00122)
- Received Army SBIR, Army STTR and DARPA SBIR contracts for further work on GaSb thermophotovoltaic cells for terrestrial military applications
- Received two Department of Energy (DOE) contracts for terrestrial applications of the GaSb photovoltaic cell
- Received commercial contract for terrestrial market
- Company personnel increased from 3 to 15

GOVERNMENT/SCIENCE APPLICATIONS

- Concept is applicable to a wide variety of NASA space missions (i.e. deep space, high radiation) with significant cost savings potential and increased performance
- Applicable to many military missions for space power generation and terrestrial stand-alone TPV systems
- GaSb cell is a key component for thermophotovoltaic power generation applications

Glenn Research Center
Space Power
3-067

1992 Phase II, NAS3-27240, 5/01
NASA Contact – Michael Piszczor
Company Contact – Jason Keyes

Small Business Innovation Research

High Volume Metal Organic Chemical Vapor Deposition (MOCVD) Device Wafer Production

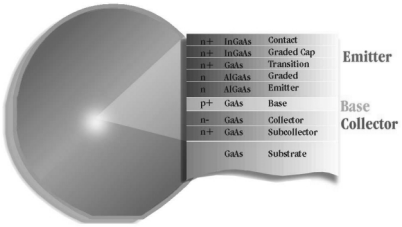
Kopin Corporation
Taunton, MA

INNOVATION

Advanced heterostructure devices for microwave communications

ACCOMPLISHMENTS

- Introduced the first carbon-doped Heterojunction Bipolar Transistor (HBT) Device Wafer to commercial market
- Introduced InGaP HBT Device Wafer for High Reliability Applications



Epitaxial Layer Structure

COMMERCIALIZATION

- Leading provider of HBT Device Wafers in world wide markets
- Commercial sales increased 6x, from ~$3M in 1995 to est. $18M in 1998
- HBT L-Band Power Amplifiers (PA) Rapidly Penetrating Cellular Handset

GOVERNMENT/SCIENCE APPLICATIONS

- HBT Circuits used as high power X-band radar applications
- HBT will migrate to higher frequency microwave communication applications

Glenn Research Center
Energy Conversion/Communication
3-017

1986 Phase II, NAS3-25449, 9/98
1988 Phase II, NAS3-25948
NASA Contact - Dennis Flood
Company Contact - Dr. Noren Pan

Small Business Innovation Research

Advanced Electrode Materials for Lithium-ion Rechargeable Battery

Materials & Electrochemical Research (MER) Corporation
Tucson, AZ

INNOVATION

Anode materials with high capacity for lithium-ion rechargeable batteries

High Performance Lithium-ion Rechargeable Batteries

ACCOMPLISHMENTS

- Optimized the production of the unique fullerene nanotube materials
- Developed processes to purify, increase the yield, and open the closed end of the nanotubes
- Characterized the electrochemical performance of the nanotubes
- Developed electrode fabrication technology
- Assembled and tested full cells

COMMERCIALIZATION

- Commercial sales - more than $600K
- Obtained a commitment for $2.5M to develop a commercialization plan and establish a prototype production

GOVERNMENT/SCIENCE APPLICATIONS

- Aerospace batteries for use in satellites
- Low cost, and high energy density battery for portable consumer products such as cell phones, lap tops, etc.
- Use as portable power source for various military applications
- Electric vehicle application

Glenn Research Center
Space Power
3-024

1994 Phase II, NAS3-27675, 5/99
NASA Contact – Norm Hagedorn
Company Contact – Dr. R. O. Loutfy

Small Business Innovation Research

Arc Reduction Procedures for Solar Cells

Physical Sciences, Inc.
Andover, MA

INNOVATION

Solar cell construction procedure that reduces frequency of arcing in high voltage solar cells

High Voltage Arcing

ACCOMPLISHMENTS

- Developed construction method for solar cells to reduce high voltage solar cell arcing
- Developed UHV test facility and methods for evaluating the mechanism of arcing in high voltage solar cells in Low Earth Orbit (LEO)
- Successfully tested reduced arc frequency solar cells during shuttle mission

COMMERCIALIZATION

- Established testing service for alternate solar cell designs
- Sales of more than $100K for testing service

GOVERNMENT/SCIENCE APPLICATIONS

- NASA purchased test panels for $15K which were tested successfully on Space Shuttle STS-62.
- Very useful to Space Station
- Applicable to any LEO power system

Glenn Research Center
Space Power Technology

1987 Phase II, NAS3-25797, SS-175, 9/97
NASA Contact - David Snyder

Small Business Innovation Research

Electrocatalysts for High Efficiency Solid Polymer Electrolyte Fuel Cell

Physical Sciences, Inc.
Andover, MA

INNOVATION

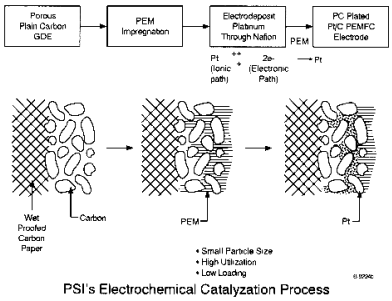
Electrochemical catalyzation (ECC) technique for producing high performance proton-exchange membrane electrodes

ACCOMPLISHMENTS

- Improved ECC process
- Application to high surface area, high utilization, high catalyst loading electrodes demonstrated
- Specific activity improvement demonstrated

COMMERCIALIZATION

- The improved process is being qualified for commercial fuel cells by manufacturers that include International Fuel Cells and Energy Partners
- Phase III funding of $190K obtained from the Department of Energy and the State of Florida
- ECC Technology can be used to develop and manufacture lower cost, higher performance Polymer-Electrolyte membrane (PEM) fuel cells



PSI's Electrochemical Catalyzation Process

GOVERNMENT/SCIENCE APPLICATIONS

- Applications include long term Lunar and Mars missions, underwater autonomous vehicle propulsion, and terrestrial remote, and portable power

Glenn Research Center
Space Power Technology

1990 Phase II, NAS3-26699, SS-191, 9/97
NASA Contact - Dr. Richard Baldwin

Small Business Innovation Research

Pulse Power Thyristors (PPTs) for Aerospace

Power Technology South (PTS) Company
Raleigh, NC

INNOVATION

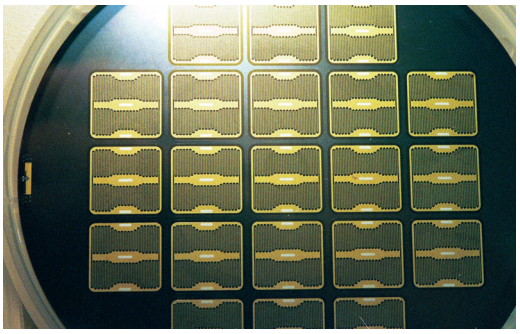
New opening and closing switch thyristor capable of unlimited di/dt blocking up to 40,000 volts

ACCOMPLISHMENTS

- Developed opening and closing switch thyristors with unlimited di/dt, blocking up to 40,000 volts in low cost plastic packages
- Developed practical use of "Pulse Power Technology" in FAA Certified ignition, Thyristor replacement, Laser Fusion, Electroporation and etc.

COMMERCIALIZATION

- Arrays of the PPTs has been used to replace Thyratrons
- PPTs currently used to replace spark gap switches in FAA Certified exciter/igniter systems to start jet engines
- PTS has allied with three major power semiconductor producers for an assured supply of PPTs
- Private capital investment has been secured to fund several new PPT applications
- As a result of this SBIR PTS Company is able to continue to exist as a commercial company



PPT Wafer

GOVERNMENT/SCIENCE APPLICATIONS

- New Government and Commercial Turbine starters use the new PPT technology
- Stacks of PPTs are used to replace Thyratron tubes
- PPT stacks are also used to initiate Inertial Confinement Fusion in the "NRL Electra" application

Glenn Research Center
Space Power
3-080

1993 Phase II, NAS3-27553, 1/02
NASA Contact – Gene Schwarze
Company Contact – John Driscoll

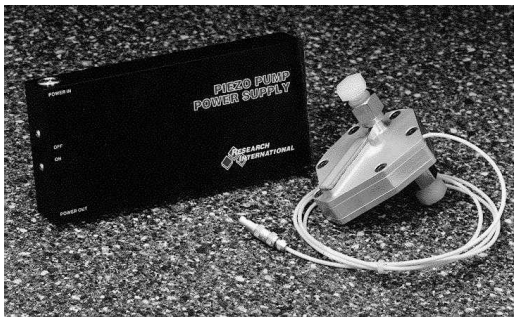
Small Business Innovation Research

Solid State Micromachined Pump

Research International
Woodinville, WA

INNOVATION

Micromachined pump with no moving parts



Micromachined pump

ACCOMPLISHMENTS

- Pumping technology incorporated into a four-channel solid-state fluorometer
- A patent is pending for this product, Analyte 2000, a portable, automated immunoassay system for the detection of toxins and pollutants
- This final product combines technology from another SBIR award from Johnson Space Center

COMMERCIALIZATION

- Commercial applications include detection of toxins and pollutants in coal mines, as well as an early warning smoke detector for industrial applications
- Company tripled in size from 10 to 30 employees with the hiring of 16 new engineers and scientists at a total cost of $2.44 M

GOVERNMENT/SCIENCE APPLICATIONS

- Micromachined pump used for cooling electronics in space
- Circulation of heat transfer fluids on spacecraft
- Monitor for fire hazards and hazardous gas releases within shipboard magazines on naval warships

Glenn Research Center
Johnson Space Center
Space Power Technology

1990 Phase II, NAS3-26610, SS-131, 3/20/97
1992 Phase I - JSC
NASA Contact - Karl Baker

Small Business Innovation Research

An Alternative Method of Producing Rhenium Combustion Chambers

Rhenium Alloys, Inc.
Elyria, OH

INNOVATION

Cold Isostatic Pressing of Rhenium Powder to a Near Net Shaped Combustion Chamber

Components made from NNS process.
1. Kaiser Marquardt chamber, 2. TRW chamber,
3. Domes made for commercial customer

ACCOMPLISHMENTS

- Developed the cold isostatic pressing (CIP) manufacturing method to produce a near net shaped (NNS) combustion chamber
- The CIP to NNS process produced a chamber with a sintered density of greater than 97% of theoretical. After hot isostatic pressing without canning the chamber obtained densities greater than 99%
- The CIP to NNS reduced the amount of rhenium powder used by 70%. This process reduced the manufacturing time by 30% and the machining time by 50%. The overall savings to commercial customers was 35%

COMMERCIALIZATION

- Flight qualification testing by General Dynamics (formerly Kaiser Marquardt) is scheduled in late 2001 and the TRW chamber will be flight tested in 2002
- The CIP to NNS method of manufacturing was used to produce two hemispherical domes for a commercial customer. This method has increased the job equivalents by 1, which is directly associated with this SBIR

GOVERNMENT/SCIENCE APPLICATIONS

- NASA requires rhenium for many space applications such as solar thermal propulsion and liquid fueled thrusters for satellite position system
- Various DoD agencies require lower cost production methods for several rhenium applications such as tactical missile components and other high temperature or thermally cycled parts

Glenn Research Center
Power and On-Board Propulsion
3-033

1995 Phase II, NAS3-97036, rev. 8/01
NASA Contact – James Biaglow
Company Contact – Todd Leonhardt

Small
Business
Innovation
Research

Carbon Fiber Flywheel for Power Generation and Attitude Control

SatCon Technology Corp.
Cambridge, MA

INNOVATION

A 2 Kw/hr carbon fiber flywheel capable of
power over a speed range of 20,000-40,000 rpm

ACCOMPLISHMENTS

- The round trip efficiency of the energy storage wheel, including power conditioning electronics, is expected to exceed 85%
- The flywheel is supported on magnetic bearings which reduce the parasite losses of the system

COMMERCIALIZATION

- Technology is directly applicable to the flywheel energy storage program SatCon currently has with Chrysler's Patriot project, a high performance hybrid electric race vehicle, that uses flywheel storage to improve the efficiency by load-leveling a turbine-alternator
- Pursuing customers such as public utilities for use as a load leveling intermediate energy storage device, and for uninterruptible power supplies

SatCon Flywheel Energy Storage System

GOVERNMENT/SCIENCE APPLICATIONS

- Flywheel is aimed toward a combined energy storage and attitude control system which can be used on ISSA as well as all types of NASA, commercial, and military spacecraft ranging from low power communication or observing spacecraft to orbital platforms
- SatCon is committed to developing flywheel products for automotive, industrial, utility and aerospace applications

Marshall Space Flight Center
Glenn Research Center
Space Power Technology

1989 Phase II, 1990 Phase I; SS-67; 8/96
NASA Contact – Ray Beach

Small
Business
Innovation
Research

Improved Mirror Facet

Solar Kinetics
Dallas, TX

INNOVATION

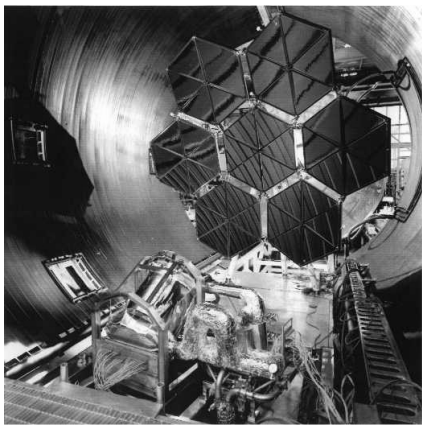
A spin coating process for depositing aluminum on an all metal honeycomb structure to produce high precision mirrors

ACCOMPLISHMENTS

- Demonstrated high precision mirrors can be produced by depositing aluminum on a metallic honeycomb by a spin coating process
- Further improvements were validated in a 2 kW test
- Developed an ultra-lightweight scaled parabolic mirror facet with a specific weight of 1.8kg/m2 with a reflectivity greater than 85%

COMMERCIALIZATION

- Sale of $1 M to Harris Corporation to build panels for use on Space Station
- Terrestrial applications include solar concentrators for solar powered waste detoxifiers
- Created three new jobs



Solar Dynamic Ground Demonstration Unit

GOVERNMENT/SCIENCE APPLICATIONS

- Government uses include; Space Station, advanced space telescopes and lightweight antenna dishes
- Very efficient, high quality concentrator is important to NASA's Solar Dynamics Program for both space and terrestrial applications

Glenn Research Center
Space Power Technology

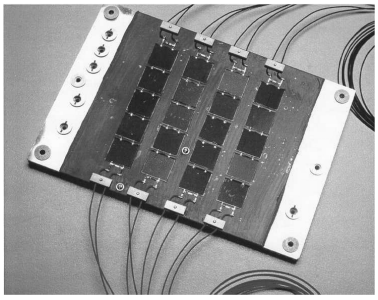
1987 Phase II, NAS3-25632, SS-26, 4/17/97
NASA Contact - James E. Calogeras

Small Business Innovation Research

High Efficiency, Radiation-Resistant Indium Phosphide Solar Cells

Spire Corporation
Bedford, MA

INNOVATION
Space solar cells having superior radiation resistance for missions in high radiation environments



Indium phosphide Solar Cells

- Achieved world record conversion efficiency (>19%) for indium phosphide (InP) cells
- Confirmed radiation hardness by actual flight experiment Photovoltaic Array Space Power Plus Diagnostic (PASP-Plus)
- Basis for current proposal to NASA for a reduced-cost concentrator array

COMMERCIALIZATION

- Led to successful NASA and Navy-sponsored cell development programs using 90% less expensive silicon substrates

GOVERNMENT/SCIENCE APPLICATIONS

- Long-life, reliable photovoltaic power for commercial, military, and NASA satellites in medium-to-high radiation environments (e.g., MEO, GEO, or high LEO)

Glenn Research Center
Space Power Technology

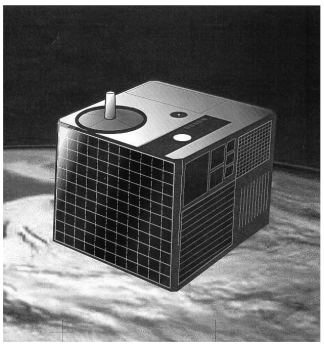
1984 Phase II; NAS3-24857, 12/97
NASA Contact - Dennis Flood

Small Business Innovation Research

Indium Phosphide Solar Cells on Silicon Substrates

Spire Corporation
Bedford, MA

INNOVATION
Lightweight, reduced-cost solar cells for high radiation environment space flight missions.



Satellite with Indium Phosphide on Silicon Substrate Solar Cells

ACCOMPLISHMENTS

- Achieved significant reductions in cell weight (~50%) and substrate cost (>90%)
- NASA program led to additional Navy-sponsored advanced development
- Follow-on program achieved record high conversion efficiency (~13%)

COMMERCIALIZATION

- Flight panel currently under construction for a high radiation mission Space Technology Research Vehicle (STRV 1-C/D) being funded by a $370K Navy contract

GOVERNMENT/SCIENCE APPLICATIONS

- Affordable photovoltaic power for long duration missions in medium-to-high radiation orbits.
- Technology currently being evaluated by at least three solar cell suppliers and users

Glenn Research Center
Space Power Technology

1987 Phase II; NAS3-25798, 12/97
NASA Contact - Dennis Flood

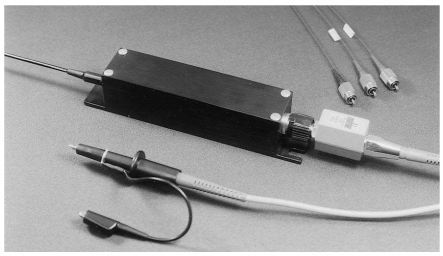
Small
Business
Innovation
Research

Integrated Optical Voltage Measurement System

Srico, Inc.
Columbus, OH

INNOVATION

Voltage sensor probe that allows isolation from electromagnetic interference by converting the electrical signal to an optical signal



Voltage Sensor Probe

ACCOMPLISHMENTS

- Integrated optic high voltage probe with optical signal transmission, eliminates the need for high voltage leads from source to readout
- Optical isolation reduces the safety problems associated with high voltage
- The problem of electrical noise and electromagnetic interference was eliminated as well as problems associated with vibration
- Improved measurement accuracy

COMMERCIALIZATION

- Large scale production of an inexpensive robust probe will be initiated
- Over $1M in sales expected the first few years of production
- Electrical distribution companies will use this system in their power distribution facilities

GOVERNMENT/SCIENCE APPLICATIONS

- Well suited to NASA's stringent requirements for automatic control of aeronautic or space power management and distribution systems
- Kennedy Space Center - for lightning and thunderstorm detection
- Space station power system
- Electromagnetic compatibility testing
- Physiological monitoring of astronauts

Glenn Research Center
Space Power Technology

1993 Phase II, NAS3-27273, SS-45, 9/98
NASA Contact - Richard Patterson

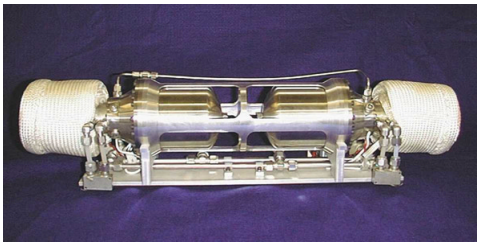
Small
Business
Innovation
Research

Stirling Convertor for a Radioisotope Power System

Stirling Technology Company (STC)
Kennewick, WA

INNOVATION

Stirling as a potential high-efficiency radioisotope power system (RPS) for deep space missions and Mars rovers



Two 55-We Stirling Convertors for a Stirling RPS

ACCOMPLISHMENTS

- Developed method to synchronize two thermodynamically independent free-piston Stirling power convertors
- Resolved key issue by reducing vibrations 40-50 fold by synchronizing convertors
- Adaptive Vibration Reduction System can further reduce vibrations and adds potential to balance in unlikely event of a failed convertor
- Initiated design of current Stirling convertor for RPS

COMMERCIALIZATION

- STC has developed product lines for both Stirling power sources and cryocoolers, based directly on multiple SBIR's
- Generated over $9M in commercial revenue to date
- Received Phase III funding of $3.3M to date plus $2M backlog and more than $17M pending from DOE and NASA for the radioisotope space power application
- ENATEC, a European micro co-gen consortium, has licensed STC RG-1000 for residential cogeneration to produce >100,000 units per year beginning in 2003

GOVERNMENT/SCIENCE APPLICATIONS

- Led to major DOE/NASA project to develop Stirling RPS - DOE/NASA are further developing convertor
- System integrator now being selected by DOE for flight systems
- Near term high-efficiency RPS for NASA deep space missions - Potentially can save tens of millions of dollars per mission.
- Enabling technology under consideration for Mars rovers for long duration missions

Glenn Research Center
Space Power
3-063

1994 & 1996 Phase II, NAS3-27817 & 98016, 5/01
NASA Contact – Lanny Thieme
Company Contact – Maurice White

Small Business Innovation Research

Measuring Reversing Flow Pressure Drop in Stirling Engine Heat Exchangers

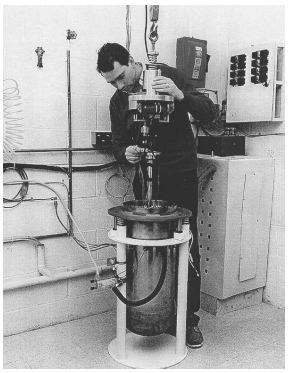
Sunpower, Inc.
Athens, OH

INNOVATION

A unique flexible rig for measuring pressure drop in oscillating flows

ACCOMPLISHMENTS

- Developed an oscillating flow test rig to measure pressure variations in complex engine flows
- Provided insights into flow effects in Stirling engine heat exchanger
- Provided much improved understanding of one of the primary losses in Stirling cycle machines



Oscillating Flow Test Rig

COMMERCIALIZATION

- Improved performance of both Stirling-cycle engines and Stirling-cycle coolers; hence this SBIR has resulted in the continued support from private industry
- Resulted in another SBIR and a University grant that allowed rig modification to also measure oscillating flow heat transfer in regenerators
- Information derived from measurements was incorporated into Stirling computer codes that are being used to design Stirling engines and coolers by private companies

GOVERNMENT/SCIENCE APPLICATIONS

- Stirling engines are a leading candidate for dynamic space power systems - Stirling has been chosen as a backup for the Advanced Radioisotope Power System (ARPS) being developed for deep-space missions
- Stirling engines are applicable for use in terrestrial dynamic power, including remote power generation and cogeneration

Glenn Research Center
Space Power Technology

1984 Phase II, NAS3-24879, 12/97
NASA Contacts - Roy Tew and Lanny Thieme

Small Business Innovation Research

Regenerative Solid Oxide Fuel Cell Technology Development

Technology Management, Inc.
Cleveland, OH

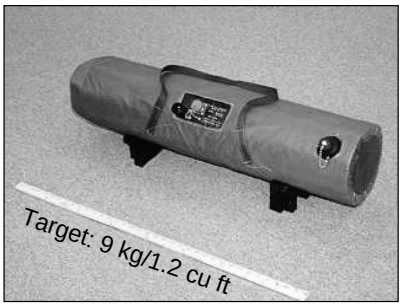
INNOVATION

Solid oxide fuel cell (SOFC) and electrolysis that is combined into a high-efficiency energy storage system

Sulfur-tolerant integrated SOFC/reformer technology that can operate using common hydrocarbon fuels including logistic fuels and biogas

ACCOMPLISHMENTS

- Improved system operation and efficiency
- Scalable fuel cell component technologies
- Integrated systems packaging
- Developed for small, low weight and volume applications



DARPA 500 Watt Portable Power System Mock-up

COMMERCIALIZATION

- Continued support from both commercial (EPRI, GRI, other) and government (DARPA, Navy, NASA, USDA, DOE) contracts to serve multiple portable and stationary applications operating multiple fuels including military logistic fuels and biogas

GOVERNMENT/SCIENCE APPLICATIONS

- Ultra-small, low maintenance, stationary electric power generation applications (down to 100 Watts) operating on multiple sulfur-bearing fuels
- Military (logistic fuel) portable and mobile applications
- Low earth orbit (LEO) and other satellite power applications
- Water electrolysis for the production of hydrogen

Glenn Research Center
Energy Conversion
3-032

1993 Phase II, NAS3-27546, 2/99
NASA Contact - Mark Hoberecht
Company Contact - Benson P. Lee

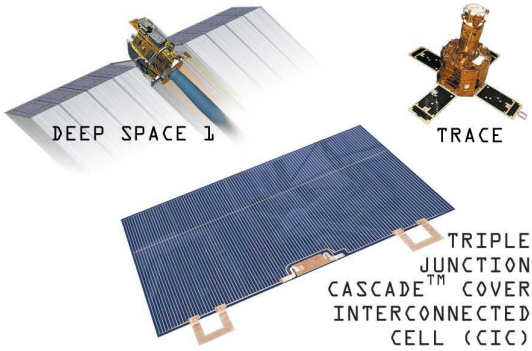
Small
Business
Innovation
Research

26 Percent Efficient, Triple Junction Cascade® Space PV Solar Cells

TECSTAR, Inc.
City of Industry, CA

INNOVATION

Total integration of the research approach with manufacturability of current dual-junction cell production with future triple-junction cell enhancement



ACCOMPLISHMENTS

- Optimized a two-junction GaInP$_2$/GaAs Cascade® solar cell
- Integrated a Ge cell as the third lower cell
- Built a multijunction Cascade® solar cell that exceeded the 26% efficiency goal, presently 27.1% efficient
- Validated the multijunction Cascade® cell for space qualification & production readiness

COMMERCIALIZATION

- Doubled solar cell capability. Very firm market for low earth orbit and synchronous orbit applications
- Supplied GRC with a small array after Phase II
- Production orders exceeding $50M ongoing in support of a leading satellite prime contractor through 2001
- Delivered four flight qualified multijunction solar panels to NASA for $100K contract price. Will fly on NASA/DOD/DERA STRV-C/D Satellites in year 2000

GOVERNMENT/SCIENCE APPLICATIONS

- Temperature and radiation characteristics of these solar cells are advantageous for near sun missions and high voltage operation
- Important to payload capabilities of very small satellites
- Will reduce cost of launch and station keeping

Glenn Research Center
Space Power
3-040

1994 Phase II, NAS3-27674, rev. 11/99
NASA Contact – Dr. Sheila Bailey
Company Contact – Dr. Patrick Park

Small
Business
Innovation
Research

Lightweight Structural Foams from Ceramic Materials

Ultramet
Pacoima, California

INNOVATION

Very lightweight ceramic foams as substrates for reflectors used in space-based solar power systems

ACCOMPLISHMENTS

- Developed technology to produce lightweight open-cell structural foams from ceramic materials such as boron carbide, silicon carbide, and hafnium carbide
- Produced lightweight, high quality reflectors using silicon carbide-hafnium carbide foam substrates with aluminum-coated quartz mirror faceplates
- Ultimately spun off foam technology into medical field, as Hedrocel™ synthetic bone material

COMMERCIALIZATION

- Licensed medical foam technology to Implex (Allendale, NJ), a manufacturer of musculoskeletal implants. Implex has invested $10 million in production facilities and experimental trials. Implex 1996 sales were nearly $1.5 million, with 1998 sales projected at $20-30 million
- Formed joint venture, Cytomatrix (Cambridge, MA), to develop biological cell growth medium using foam technology
- To date, 6 jobs at Ultramet, 30 jobs at Implex, and 4 jobs at Cytomatrix have been created

Lightweight Mirror Structure with Aluminum-Coated Quartz Mirror Faceplate

GOVERNMENT/SCIENCE APPLICATIONS

- Primary NASA application is in solar concentrators for advanced solar dynamic power systems
- Can also be used in solar collectors for ground-based solar power systems

Glenn Research Center
Materials

1986 Phase II, NAS3-25418, SS-177, 8/97
NASA Contact - Jim Calogeras

INSTRUMENTATION AND CONTROLS

Small Business Innovation Research

High Temperature Combustion Diagnostic Method Utilizing Rayleigh Scattering

Aerodyne Research, Inc.
Billerica, MA

INNOVATION

A Dual-Line Detection Rayleigh scattering technique using a copper vapor laser for non-intrusive temperature measurements in combustor flows

ACCOMPLISHMENTS

- Developed a Dual-Line Detection Rayleigh scattering technique to allow subtraction of surface scattering background noise from Rayleigh scattering signals
- Designed and tested an instrument using this Rayleigh scattering technique for non-intrusive measurement of combustor exhaust gas temperatures

COMMERCIALIZATION

- Provides a non-intrusive tool for dynamic time resolved measurement of gas turbulence and temperature
- Technique could be used in research for density measurement and mole fraction of gases
- Research test data is available to industry

Rayleigh Scattering Probe

GOVERNMENT/SCIENCE APPLICATIONS

- System was delivered to NASA Lewis Research Center where it was successfully used on a research combustor
- The technique and research results were passed-on to Polytechnic Universtiy and Air Force Wright Laboratories for use in temperature and turbulence studies of gas flows and for further development of the technique

Glenn Research Center
Instrumentation & Controls

1983 Phase II, NAS3-24613, SS-179, 9/97
NASA Contact - Richard Seasholtz

Small Business Innovation Research

Optimization of Silicon Carbide Production

Aerodyne Research, Inc.
Billerica, MA

INNOVATION

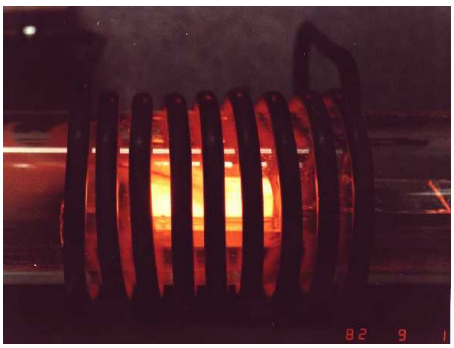
Combining gas phase calculations with experimental observations of surface reactions into a predictive model to optimize chemical vapor deposition (CVD) of silicon carbide

ACCOMPLISHMENTS

- Developed a computer code to model epitaxial Beta-SiC growth in a chemical vapor deposition process
- A 2-D predictive model of Beta-SiC growth in a chemical vapor disposition reactor was delivered to NASA Lewis
- Co-authored a paper with Lewis comparing model with experimental results from Lewis

COMMERCIALIZATION

- Code was used in development of a methane arcjet for space propulsion
- Received $25K in development funding from the Navy and $35K in commercial sales
- Computer models have application for improved high temperature electronic devices
- Work done under this SBIR project is still cited by researchers involved in SiC CVD modeling
- Received a related SBIR from Air Force Office of Scientific Research (AFOSR)



Heated Susceptor in CVD Facility

GOVERNMENT/SCIENCE APPLICATIONS

- The code was used by NASA Lewis to optimize production of single crystal semiconductors for high temperature electronic devices
- Results from this SBIR are still used by researchers involved in SiC CVD modeling
- Silicon carbide is an important electronic material for advanced aerospace applications that involve high temperature, high power and high frequency

Glenn Research Center
Instrumentation and Controls
3-001

1984 Phase II, NAS3-24891, SS-190, 12/97
NASA Contact – Maria Kuczmarski
Company Contact – Laurie Dean

Small Business Innovation Research

Turbomachinery Flowfield Temperature Measurement Linear Imaging Diagnostics

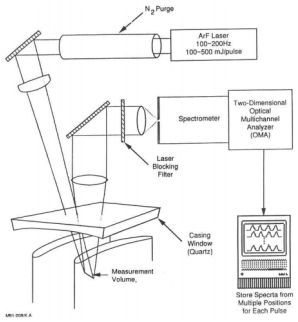
Aerodyne Research, Inc.
Billerica, MA

INNOVATION

Non-intrusive measurement of gas temperature and/or density for use in turbomachinery

ACCOMPLISHMENTS

- Demonstrated the feasibility of non-intrusive measurement of temperature and density in a flowing gas stream
- Developed an optical measurement technique for use in compressor flow fields



Linear Imaging Temperature Measurement System Design

COMMERCIALIZATION

- $11K Phase III funding for further development of the temperature measurement system at Glenn's compressor test facility
- A new approach for non-intrusive measurement of gas temperature based on an O_2-LIF technique has been demonstrated at GRC as a result of the Phase III funding
- GRC may use additional Phase III funds for demonstration tests in a compressor after reviewing results in the final report

GOVERNMENT/SCIENCE APPLICATIONS

- This technique will be used in the "Smart Green Engine" Program
- Will be used in the NASA Physics and Process Modeling Program (PPM)
- Useful in turbomachinery research over a temperature range of 300K-500K
- Useful in research applications requiring non-intrusive measurement of gas temperature

Glenn Research Center
Instrumentation
3-034

1991 Phase II, NAS3-27000, 6-99
NASA Contact - Mark P. Wernet
Company Contact - Kurt D. Annen

Small Business Innovation Research

Microscopic and Macroscopic Modeling of Layer Growth Kinetics and Morphology in Vapor Deposition Processing

CFD Research Corporation
Huntsville, Alabama

INNOVATION

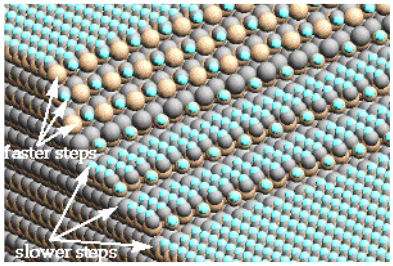
Simulation tool (CFD-FILM) to enable development of new materials for semiconductor and opto-electronic applications, as well as for structural and thermal barrier coatings

ACCOMPLISHMENTS

- Developed a Monte Carlo microscopic model to simulate specific morphological characteristics of film growth such as step bunching, thermal roughening, polytype growth, growth uniformity, defect formation, etc.
- Created a commercial software, CFD-FILM, to analyze morphology of growing films
- Validated the microscopic model against experimental data for materials such as Si, diamond and SiC
- Coupled CFD-FILM with a general purpose macroscopic transport/chemistry software, CFD-ACE

COMMERCIALIZATION

- Contributed to increased sales of CFD-ACE to leading semi-conductor equipment vendors and process designers (~$500K/year)
- CFD-FILM is marketable as a stand-alone module, as well as an add-on module with CFD-ACE
- Application projects from industry and research projects from government agencies



Simulation of Step Bunching in SiC Growth (using CFD-FILM)

GOVERNMENT/SCIENCE APPLICATIONS

- Provides an enabling technology for advanced materials such as GaN, GaAs, InP, and SiC
- Provides a base technology for extension to plasma-substrate interactions in low pressure etch processes

Glenn Research Center
Instrumentation & Controls
3-005

1992 Phase II, NAS3-27287, SS-, 2/6/98
NASA Contact - Arnon Chait or Maria Kuczmarski
Company Contact - Dr. Anantha Krishnan

Small Business Innovation Research

Blackbody High Temperature Optical Sensor

Conax Buffalo Technologies L.L.C.
Buffalo, NY

INNOVATION

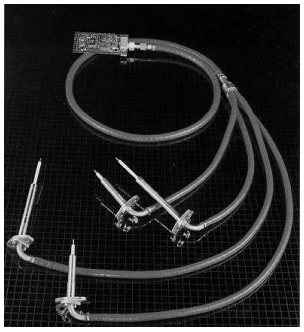
An optical sensor system for gas pass temperatures utilizing a thermally emissive insert imbedded in a sapphire lightguide

ACCOMPLISHMENTS

- Sensing element has a time constant less than one second, a diameter of 0.06 inches and has been tested at temperatures up to 1500°C
- Calibrated sensor under static conditions against thermocouples, accuracy is estimated to be +18° C

COMMERCIALIZATION

- Complete optical sensor systems have been fabricated for commercial use
- Large scale production of optical sensor systems for commercial and government use is in progress
- A Phase III effort of qualifying this optical sensor system for use commercially was financed by Electric Power Research Institute (EPRI), GE Aircraft Engines IR&D, and NASA
- More than $500K was received for optical sensor qualification and other commercial sales



Military Aircraft Fiber Optic Exhaust Gas Temperature Sensor System

GOVERNMENT/SCIENCE APPLICATIONS

- Hardware was developed for the NASA Fiber Optic Control Systems Integration (FOCSI) Program
- Development programs are ongoing for use of this system in military aircraft and ground based power generation turbines

Glenn Research Center
Instrumentation & Controls

1986 Phase II; NAS3-25451, SS-156; 3/24/97
NASA Contact - Robert Baumbick

Small Business Innovation Research

High Temperature, Silicon Carbide, Power MOSFET

Cree Research, Inc.
Durham, NC

INNOVATION

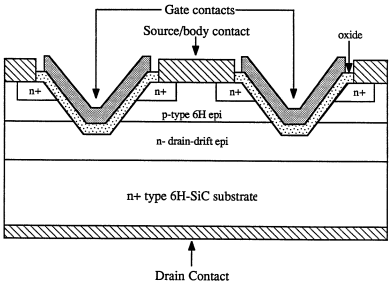
A process for producing high performance power metal/oxide semiconductor field-effect transistors (MOSFETs) in Silicon Carbide (SiC)

ACCOMPLISHMENTS

- Demonstrated the first vertical power MOSFET in SiC
- Fabricated a high-performance MOSFETs in SiC that can operate up to 300°C
- Received Patent on this technology

COMMERCIALIZATION

- Increased SiC material and device sales by >$3M
- Created 12 new jobs and saved existing jobs
- Initiated tremendous worldwide interest in the area of SiC power semiconductors, resulting in multi-$M programs in SiC MOSFETs for government and commercial labs
- Total market potential for SiC Power MOSFETs would be >$2B



Cross-Section of a SiC Power MOSFET

GOVERNMENT/SCIENCE APPLICATIONS

- Will be used in aircraft engines
- Applicable for high temperature electronics in space craft and will reduce weight and size of spacecraft
- Can be used to replace Silicon power devices in power circuits for electric motors and power control, for electric vehicles, robotics, and power supplies
- SiC MOSFETs offer much higher efficiencies than silicon in these applications. Potential power savings of >$1B/yr are possible

Glenn Research Center
Instrumentation and Controls
3-021

1988 Phase II, NAS3-25956 , 9/98
NASA Contact - Lawrence Matus
Company Contact - John Palmour

Small
Business
Innovation
Research

6H-SiC Pressure Sensors for High Temperature Applications

Kulite Semiconductor Products, Inc.
Leonia, NJ

INNOVATION

A silicon carbide (SiC) pressure sensor for use at temperatures as high as 500°C, which is approximately 100°C higher than can be withstood by presently available silicon pressure sensors

ACCOMPLISHMENTS

- Prototype SiC pressure sensors were developed in Phase II contract
- The pressure sensors were shown to be capable of operating at 500°C for several hours
- Provided GRC with prototype SiC pressure sensors

COMMERCIALIZATION

- A high temperature pressure sensor for engine aircraft development and test. Fast response pressure measurements in the compressor hot section for stall detection and control
- This pressure sensor can be used for other high temperature turbine engine applications

SiC Sensor Mounted on a Header

GOVERNMENT/SCIENCE APPLICATIONS

- Phase III of $500K to provide GRC with 6-10 prototype SiC pressure sensors. Funding provided by Advanced High Temperature Engine Material Technology Program (HITEMP) and Higher Operating Temperature Propulsion Components (HOTPC) Program.
- A prototype SiC pressure sensor was successfully tested at Honeywell in Phoenix, AZ in September 2000 and at P&W, Florida on a PW2098 engine in August and September, 2001. Test was part of a GRC's EVNRC (Engine Validation of Noise Reduction Concept) program

Glenn Research Center
Instrumentation
3-046

1991 Phase II, NAS3-27011, rev. 2/02
NASA Contact – Glenn Beheim
Company Contact – Alex Ned

Small Business
Technology
TRansfer

Robust Exhaust Gas Sensing System Using Advanced Thin Film Chemical Sensors

Makel Engineering, Inc.
Chico, CA

INNOVATION

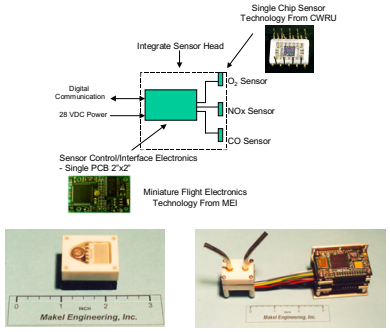
Low cost, miniature, MEMs based chemical sensor system for monitoring key exhaust species. (Oxides of nitrogen – NOx, carbon monoxide – CO, oxygen – O_2)

ACCOMPLISHMENTS

- Prototype Micro Electro Mechanical Systems (MEMS) sensor module demonstrated with full integrated "smart sensor" electronics
- Bench and feasibility testing successfully completed
- Sensor system performance demonstrated in engine testing conducted with gas turbine engine
- Partnered with Case Western Reserve University

COMMERCIALIZATION

- Testing planned with a manufacturer of large stationary gas turbines and manufacturer of microturbines for distributed power generation
- Joint development agreement with a major Ohio based fuel products OEM for application to exhaust measurements in reciprocating engines
- Production facility to support production up to 20,000 units per year, is under construction
- Phase III funding of $170K from NASA Glenn



GOVERNMENT/SCIENCE APPLICATIONS

- Jet engine emissions monitoring for NASA
- Arnold Engineering and Development Center/U.S. Air Force for performance measurements (thrust and combustion efficiency) in exhaust of vectored jet engines with afterburner
- EPA and DOE for NOx measurements of diesel engines
- Potential application to indoor air quality monitoring in buildings and vehicles

Glenn Research Center
Instrumentation and Controls
3-070

1998 Phase II, NAS3-00107, 4/01
NASA Contact – Mr. Gus Fralick
Company Contact – Dr. Darby Makel

Small
Business
Innovation
Research

Multiple Beam Spectroscopy for Liquid Rocket Engine Diagnostics

Science Research Laboratory
Somerville, MA

INNOVATION

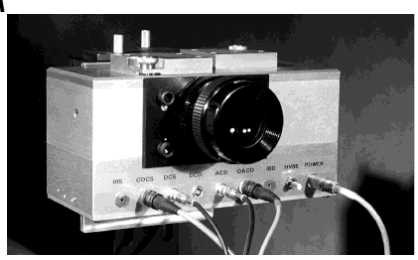
A non-intrusive optical technique for measuring velocity of luminous gases

ACCOMPLISHMENTS

- An image of the gas was divided into narrow strips and directed into alternate photodetectors. The frequency difference of the two measured light intensities shows the gas velocity
- An instrument using transmission gratings and a new three-cube beamsplitter was engineered, fabricated and tested in Phase II
- Complete instrument, and calibration equipment delivered to NASA Glenn for study of rocket engine exhausts

COMMERCIALIZATION

- An instrument is on loan to Microcoating Technologies, who are marketing a novel combustion coating system for possible inclusion in the control system of their product
- Instrument based on the same principle is being fabricated for the Federal Highway Administration (FHWA)



A Complete Detector Head

GOVERNMENT/SCIENCE APPLICATIONS

- Based on this SBIR an instrument was fabricated and delivered to the Plasma Fusion Center at MIT and used for diagnostics on the Alcator Tokamak
- The technique has been extended to nonluminous gases. Such measurements were made for NASA Langley and for Arnold AFB. SRL has now proposed to deliver a velocimeter to the FHWA to map the air flow in their wind tunnel

Glenn Research Center
Instrumentation and Controls
3-057

1991 Phase II, NAS3-27001, 10/00
NASA Contact – Steven J. Schneider
Company Contact – Peter Rostler

COMMUNICATIONS

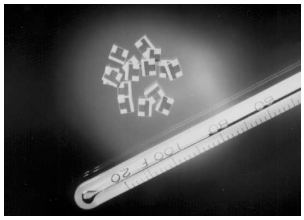
Small Business Innovation Research

Passive Temperature Compensating Attenuator

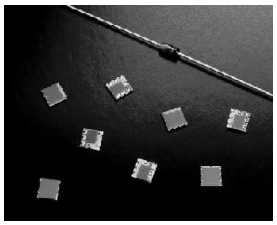
EMC Technology, Inc.
Cherry Hill, NJ

INNOVATION

A family of passive high frequency temperature compensation attenuators (Thermopad ®)



Thermopad ®



Smartload ®

ACCOMPLISHMENTS

- A 25% improvement in temperature compensation
- The development of high Temperature Coefficient of Resistance (TCR) thick film materials
- High frequency attenuator designs
- Automated high frequency measurement development
- Power Sensing Termination (SmartLoad ®) development

COMMERCIALIZATION

- ~ $1 Million in commercial sales in 1997
- 10 new jobs at EMC Technology, Inc.

GOVERNMENT/SCIENCE APPLICATIONS

- Components are currently flying on four different military and commercial satellite programs including:
  - IRIDIUM, Motorola telecommunications satellite
  - VMISAT, European meteorological satellite
  - INTELSAT, Global Star telecommunications satellite
  - INMARSAT, Lockheed Martin telecommunications satellite

Glenn Research Center
Technical Area - Satellite Communications
3-010

1993 Phase II , NAS3-27656, 5/98
NASA Contact - Gerald Chomos
Company Contact - Joseph Mazzochette

Small Business Innovation Research

RF Components for Satellite Communications System Using Insular Guides

Epsilon Lambda Electronics Corp.
Geneva, IL

INNOVATION

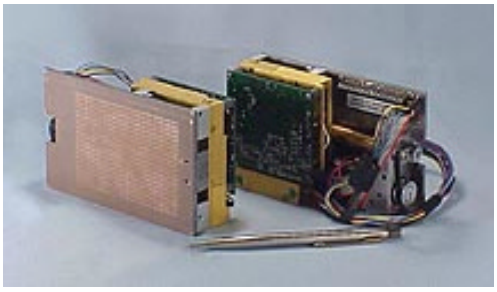
Low loss ceramic insular waveguide feed lines for phase scanned patch array antennas in the Ka Band

ACCOMPLISHMENTS

- Beam scanning in two planes was demonstrated by simple mechanical motion of a conducting image plane
- Ceramic insular guides gave higher efficiency than microstrip feed lines in aperture-fed patch array antennas
- A slight mechanical displacement of a conducting image plane phase shifts in the antenna and allows beam steering of the energy radiated
- The principle of the innovation was demonstrated in the 64 element scanned array antenna that was delivered to Glenn Research Center

COMMERCIALIZATION

- A $750K Air Force contract was awarded to develop a W-band (76 GHz) phase scanned antenna with transceiver for automotive forward looking radar market for use in intelligent cruise control
- Received $1.2M under Fast Track funding for a companion commercialization contract
- Two antenna/transceiver models were fabricated, delivered and tested on a automobile by the commercialization customer



W-band phase scanned antenna with transceiver

GOVERNMENT/SCIENCE APPLICATIONS

- The phase-scanned antenna has been patented and has potential application to radar and communication throughout the millimeter frequency bands
- Applications include space communications, tactical radar target seekers, and short range radar

Glenn Research Center
Communications
3-062

1992 Phase II, NAS3-27412, 1/01
NASA Contact – Afroz Zaman
Company Contact – Robert Knox

Small
Business
Innovation
Research

Oxide Cathodes

FDE, Inc.
Beaverton, OR

INNOVATION

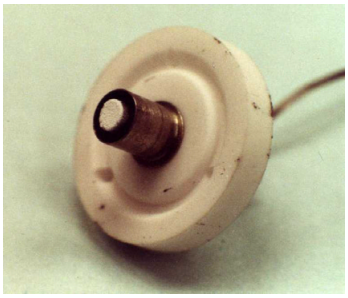
High performance miniature oxide cathodes as electron sources in displays and microwave amplifiers

ACCOMPLISHMENTS

- Addition of both indium and scandium oxide to normal material enhanced emission and longevity
- Developed a miniature cathode support structure for high volume production that dissipates less than half watt of heater power
- Combined cathode coating and support structure to provide high manufacturability, low cost, high emission current density and long life

COMMERCIALIZATION

- Cathode support structure and cathode coatings are used in an e-beam system for curing inks and dyes, in CRT's, and for traveling wave tube (TWT) amplifiers for instrumentation applications
- Various adaptations of prototype resulted in revenues of about $40K per year
- Companies that have purchased various aspects of this technology include Brimar Ltd, Tektronix, Radiant Labs Inc. and Candescent Technologies



Miniature Oxide Cathode

GOVERNMENT/SCIENCE APPLICATIONS

- 40 watt TWT for military uses in which heater power requirements were too low for use of dispenser cathodes
- Exploratory program to replace cathodes in high power klystrons with less expensive alternative
- Versions of this technology were installed in cathode ray tubes for military helmet mount displays

Glenn Research Center
Communications
3-056

1990 Phase II, NAS3-26395, 9/00
NASA Contact – Ed Wintucky
Company Contact – Bernard Vancil

Small
Business
Innovation
Research

Near Hermetic Packaging Technology For MMIC Devices

Foster-Miller, Inc.
Waltham, MA

INNOVATION

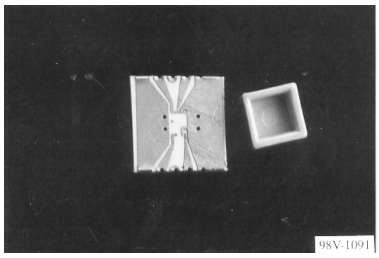
Excellent Electrical and barrier properties of Liquid Crystal Polymers (LCP) are exploited to provide Light Weight, Low Cost, Near-Hermetic Packages for High Frequency Applications

ACCOMPLISHMENTS

- Developed processes to fabricate low loss, controlled impedance transmission lines on LCP films
- Packaged and Tested a Triquint Low Noise Amplifier (LNA) using flip chip technology. Coefficient of Thermal Expansion matched LCP substrate did not require underfilling
- Interconnected receiver circuit elements (mixer, LNA) on an LCP substrate and tested up to 20 GHz
- Packages are 50% less weight with potential to achieve 75% reduction in cost compared to hybrid technology

COMMERCIALIZATION

- Triquint Inc. interested in using the technology to package their integrated circuits
- Teledyne Electronic Technologies interested to be a vendor of substrates to the industry
- Superex, a Foster-Miller subsidiary, created to commercialize the LCP technology, added three new employees



High Frequency LCP Package

GOVERNMENT/SCIENCE APPLICATIONS

- LCP technology is suitable for transmit/receive (T/R) modules. Applications include NASA communication satellites, and other communication satellite systems such as Iridium, Teledesic, etc.
- Use of LCP technology for packaging will reduce the cost and weight of air-borne and space-borne electronic systems
- Keen Interest to extend the technology to digital, and mixed signal applications and ball grid array, chip scale and built-up laminate technologies

Glenn Research Center
Satellite Communications
3-019

1992 Phase II, NAS3-26968 , SS- , 5/98
NASA Contact - Afroz Zaman
Company Contact - K. Jayaraj

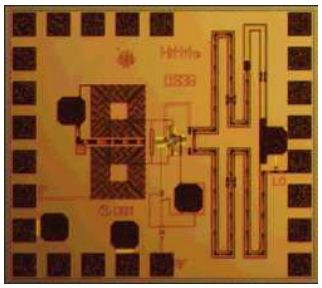
Small
Business
Innovation
Research

Millimeter Converters for Satellite Communications

Hittite Microwave Corporation
Chelmsford, MA

INNOVATION

Sub-harmonically pumped converter IC chips for K/Ka-band converters



One of The New Converters

ACCOMPLISHMENTS

- Successfully demonstrated and developed a family of fully integrated GaAs MMIC chips for millimeter wave converters with capabilities to operate with local oscillators operating at sub-harmonic frequencies

COMMERCIALIZATION

- Developed commercial products with generic application potentials in millimeter wave communication systems, including commercial Local Multi-point Distribution Systems (LMDS), 20/30 GHz VSAT/USAT ground stations, point-to-point microwave radios operating in 20-40 GHz bands
- As a result of this SBIR, Hittite introduced a family of five converters to the open market as standard commercial products. The sales volume of those parts up to October 2001 amounts to $1M
- Key customers include: Hughes, Ericsson, and Netro. Subsequent to the initial introduction of those parts, Hittite's product line for millimeter wave MMICS has been expanded to include 6 additional mixers and 4 amplifiers

GOVERNMENT/SCIENCE APPLICATIONS

- Millimeter wave communication systems will be a critical part of the future military operations providing communication links between multiples of operating units
- Millimeter wave MMIC converters will be a critical part of light-weight mobile/portable terminals for those systems

Glenn Research Center
Communications
3-075

1993 Phase II, NAS3-27657, 11/01
NASA Contact – Kul Bhasin
Company Contact – Frank Paik

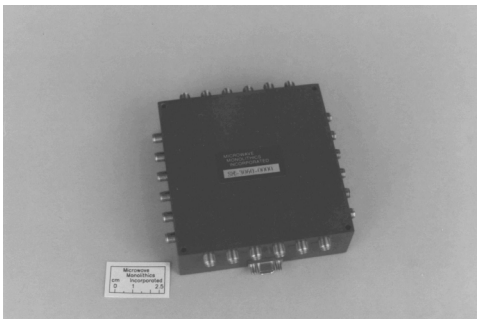
Small
Business
Innovation
Research

Advanced Monolithic GaAs IF Switch Matrix

Microwave Monolithics Incorporated
Simi Valley, CA

INNOVATION

A 3x3 monolithic microwave integrated circuit (MMIC) switch matrix implemented in gallium arsenide for wideband (3.0 - 6.0 GHz) communications applications



6 X 6 MONOLITHIC GaAs SWITCH MATRIX

ACCOMPLISHMENTS

- Monolithic implementation using gallium arsenide switching devices achieved high isolation, low loss performance
- Modular design allowed cascading of switch matrices with little signal degradation

COMMERCIALIZATION

- MMIC technology offered ten times reduction in size, weight, and power requirements over competing technology
- A Phase III NASA Lewis contract for $1.23M was received to develop a fully integrated 6X6 switch matrix
- A 6X6 switch matrix was delivered to NASA -Lewis Research Center, which performed as specified
- Marketing this product led to substantial adjunct sales of space flight GaAs MMIC based hardware

GOVERNMENT/SCIENCE APPLICATIONS

- Demonstrated that for future wideband satellites light weight, low power switch matrices can be fabricated
- Provided a building block for future microwave integrated circuits

Glenn Research Center
Communications
3-025

1983 Phase II, NAS3-24252, 11/98
NASA Contact - Gene Fujikawa
Company Contact - Daniel Ch'en

Small Business Innovation Research

High Efficiency, Low Cost Monolithic RF Module for SARSAT Distress Beacons

Microwave Monolithics Incorporated
Simi Valley, CA

INNOVATION

Miniature, ultra high efficiency GaAS MMIC components for Search and Rescue Satellite Aided Tracker (SARSAT) Distress Beacons

MicroPLB SARSAT Beacon with Internal Homing Signal and GPS Interface

ACCOMPLISHMENTS

- Developed ultra miniature Personal Locator Beacons (PLBs)
- Utilize smaller, safer batteries without performance loss

COMMERCIALIZATION

- Microwave Monolithics invested $1.2M of company resources after completion of Phase II and developed a complete MicroPLB SARSAT Beacon
- Commercial Sales of this and related technology devices exceed $1.1M to date
- Additional Government Sales of $300K directly resulted from the Phase II effort
- Substantially larger Commercial Sales projected

GOVERNMENT/SCIENCE APPLICATIONS

- The MicroPLB is a vital safety device for Military and Civilian Government personnel, providing rapid world wide notification and location information in case of emergency

Glenn Research Center
Communications
3-016

1987 Phase II, NAS3-25712 , 8/98
NASA Contact - Robert Kerczewski
Company Contact - Daniel Ch'en

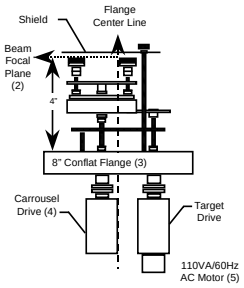
Small Business Innovation Research

Microwave-Compatible Superconducting Films

Neocera, Inc.
Beltsville, MD

INNOVATION

A process for growing high transition temperature superconducting films of yttrium-barium-copper-oxide on sapphire or lanthanum aluminate substrate



Flange Assembly for Pulsed Laser Deposition

ACCOMPLISHMENTS

- Developed innovative pulsed laser deposition hardware
- Products developed in the process include manual multilayer deposistion systems, target carrousel flange assembly, substrate heater flange assembly, and programmable substrate heater controller

COMMERCIALIZATION

- Initial sales include $55K for pulsed laser deposition hardware and $750K for high temperature superconducting film and equipment
- Sales of all the various products developed increased to approximately $3 M
- Staff was increased from 3 to 15 people

GOVERNMENT/SCIENCE APPLICATIONS

- For microwave engineering, procedure will reduce phase noise in planar microwave components such as local oscillators
- Size, weight, and microwave loss will be reduced when properly used in monolithic microwave integrated circuits
- The equipment developed can be used for material research at all temperatures
- High temperature superconducting films have been used as circuit switches using pulsed lasers to increase film temperature above critical temperature

Glenn Research Center
Materials

1989 Phase 2, NAS3-25929, SS-37, 8/97
NASA Contact - Thomas Kascak

Small Business Innovation Research

Innovative High Speed Modem for Satellite Communications

Intersil Corporation (formerly SiCOM, Inc.)
Scottsdale, AZ

INNOVATION

Very high integration of modem functions and flexible user programmability enabled by unique algorithm development and hardware implementation

SiCOM's *BitFLOW* Variable Rate Programmable Demodulator Unit and the core ASIC

ACCOMPLISHMENTS

- Developed the first commercially available 155 Mbps ASIC-based modulator and demodulator to enable next generation wideband video and data services
- Advanced the state of the art in modulation and coding technology demonstrating significant power and bandwidth efficient operation in a single integrated circuit
- Set the stage for successful integration of bandwidth on demand into home and office via inexpensive wireless modems

COMMERCIALIZATION

- $5M in Phase III monies through 1997 from SiCOM and Quantum Partners, LLC
- Sales projections are $3M for 1998 and $8M for 1999
- Projected 1998 -1999 growth from 47 to 100 (116%) employees
- Companies that use or have placed orders for BitFLOW 155 Mbps modems include R. E. America, Andrew Corp., NuComm, Dae Young, Raytheon TI, Wytek, I. O. Wave, VIS Technolgia, Multimedia Broadband Technologies, Triton Network Systems, Radyne and Texas Instruments

GOVERNMENT/SCIENCE APPLICATIONS

- Baseline modem for the NASA LeRC Direct Data Distribution (D^3) project
- Applicable to International Space Station and Earth Science missions which require wideband data service
- BitFLOW will be used at Sandia Labs. Other government agencies expressing interest include DARPA, NRO, DISA, USSPACECOM, and CECOM

Glenn Research Center
Satellite Communications
3-007

1994 Phase II, NAS3-27824, rev. 12/01
NASA Contact – Monty Andro
Company Contact – Ron McCallister

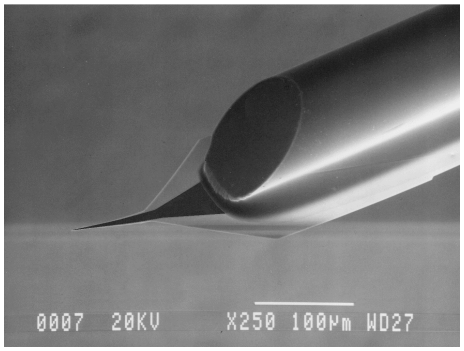
Small Business Innovation Research

1-Picosecond, High-Impedance Absolute-Voltage Probe/Pulser with 1-Microvolt Sensitivity

Picometrix, Inc. (Formerly Picotronix)
Ann Arbor, MI

INNOVATION

Ultra-high frequency electronics and submillimeter-wave probe for advanced space communication



Picosecond Probe

ACCOMPLISHMENTS

- Developed silicon-on-sapphire high-impedance probe with response time of 2 ps and 10-µV sensitivity
- Optical fiber interface was integrated with probe
- High-impedance sampling gate with 5 ps resolution and 10 µV sensitivity was developed using fiber-based probe
- Demonstrated on-wafer probing with 7 ps resolution using a 5-ps laser-activated sampling gate, combined with a 50-Ohm impedance Picoprobe

COMMERCIALIZATION

- High-impedance probe is used in the manufacture and testing of ultrafast photodectors
- Has exclusive patent license for picosecond resolution, high-impedance probe for world wide application

GOVERNMENT/SCIENCE APPLICATIONS

- NASA technology satellites
- Military satellites
- Any high frequency communications or sensing application

Glenn Research Center
Communications
3-066

1992 Phase II, NAS3-26969, 5/01
NASA Contact – Robert Romanofsky
Company Contact – Steven Williamson

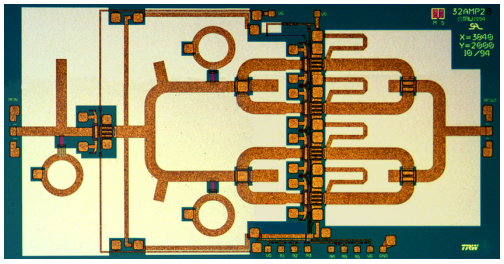
Small
Business
Innovation
Research

Ka-Band, High Efficiency Power MMIC

Schellenberg Associates
Huntington Beach, CA

INNOVATION

A high-voltage, high-efficiency integrated circuit amplifier operating at Ka-Band frequencies



High-Voltage, High-Efficiency Power IC

ACCOMPLISHMENTS

- Designed and developed an integrated circuit power amplifier for efficient conversion of DC power to 32 GHz
- Fabricated and tested an integrated circuit amplifier that produced record efficiencies (41.1%)
- Developed versions of the original IC operating at 28 and 38 GHz for commercial applications

COMMERCIALIZATION

- A marketing data sheet, for power ICs operating at 28, 32, and 38 GHz, is currently available
- Ball Aerospace and John Hopkins Applied Physics Lab have placed orders for the 32 GHz version of this IC

GOVERNMENT/SCIENCE APPLICATIONS

- Jet Propulsion Labs is interested in this work for possible use on deep space probes to the outer planets
- A direct fit into a Ka-Band satellite-to-earth downlink

Glenn Research Center
Communications
3-055

1990 Phase II, NAS3-26397, 9/00
NASA Contact – Alan N. Downey
Company Contact – James Schellenberg

TURBOMACHINERY AND PROPULSION SYSTEMS

Small Business Innovation Research

Enhanced Combustion Pulsejet Engine (ECPE) for Mach 0 to 3 Applications

Advanced Projects Research, Inc.
La Verne, CA

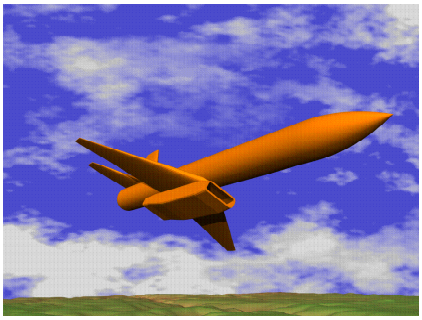
INNOVATION
An advanced pulsejet engine with modern controls was demonstrated

ACCOMPLISHMENTS

- Demonstrated ignition system for a pulsejet
- Built and tested an advanced pulsejet engine.

COMMERCIALIZATION

- Received Phase III contribution from drone manufacturer during Phase II
- Advanced Projects Research, Inc. (APRI) may be involved in NASA's plans for a $12M base R&T effort to advance this technology
- Navy and USAF are also funding the development of related technology.
- The APRI "pulsejet" technology stands as unique in the community of pulsed combustion
- Interest by drone manufacturers for use as a drone engine. Will reduce engine cost substantially



Enhanced Combustion Pulsejet Engine on Target Drone

GOVERNMENT/SCIENCE APPLICATIONS

- Engine for unmanned air vehicle (UAV) under development
- NASA's interest in using this technology as part of a combined cycle engine
- USAF interest in using this technology as a core or augmentor for a gas-turbine engine

Glenn Research Center
Turbomachinery and Propulsion Systems
3-038

1995 Phase II, NAS3-97028, 7/99
NASA Contact – H. Doug Perkins
Company Contact – Thomas H. Sobota

Small Business Innovation Research

Advanced Instrumentation for Aircraft Icing Research

Aerometrics/TSI Inc.
Shoreview, MN

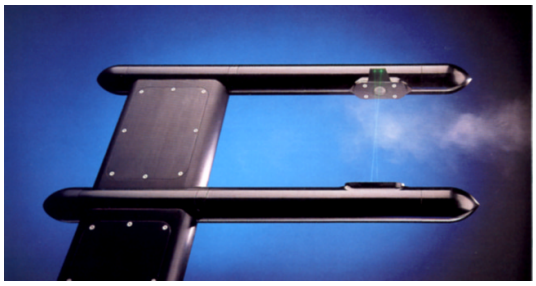
INNOVATION
An all weather instrument for measuring cloud droplets size and velocity

ACCOMPLISHMENTS

- Phase Doppler technique was successfully adapted to cloud droplet size and velocity measurement
- This instrument was successfully tested in the NASA Glenn Research Center (GRC) Icing Tunnel

COMMERCIALIZATION

- Further development of an advanced Phase Doppler signal processor was done by Aerometrics/TSI, and is presently being sold by TSI Inc.
- Aerometrics was acquired by TSI in 1996
- Boeing purchased this instrument system for cloud certification of their aircraft
- Two of these instrument systems were purchased by the Italian Government for calibrating their Icing Tunnel



ADA-100 Icing Probe of TSI

GOVERNMENT/SCIENCE APPLICATIONS

- An advanced Phase Doppler signal processor was developed under a $150K Phase III effort with GRC
- For use in the certification of commercial aircraft
- For use in cloud physics studies, including in-flight tests

Glenn Research Center
Turbomachinery and Propulsion Systems
3-045

1987 Phase II, NAS3-25635, 12/99
NASA Contact – John Oldenburg
Company Contact – Amir Naqwi

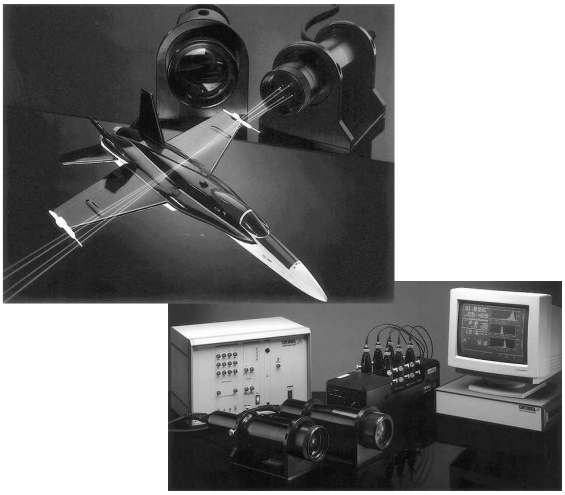
Small Business Innovation Research

Phase Doppler Particle Analyzer

Aerometrics, Inc.
Sunnyvale, CA

INNOVATION

System that provides simultaneous measurement of fuel-particle size and velocity in fuel injection systems



ACCOMPLISHMENTS

- Characterization of the complex turbulent flows in gas turbine and rocket engines
- The system includes: transmitting and receiving optics, a signal processor, system software, and a fiber drive
- This non-intrusive device has created great interest in the commercial sector attested to by its selection for the international Tanasawa Award

COMMERCIALIZATION

- Spray nozzle development for fuels, paints, agricultural materials, and medical nebulizers
- Commercial sales - more than $25 million (over $5M per year)
- Providing over 120 jobs at Aerometrics and its suppliers and distributors

GOVERNMENT/SCIENCE APPLICATIONS

- Used in the characterization of particle fields by NASA's Icing Technology Division
- Program uses include advanced subsonic transport (AST) and high speed research (HSR)

Glenn Research Center
Aeropropulsion

1985 Phase II, NAS3-25204, SS-39, 10/16/95
NASA Contact - Valerie Lyons

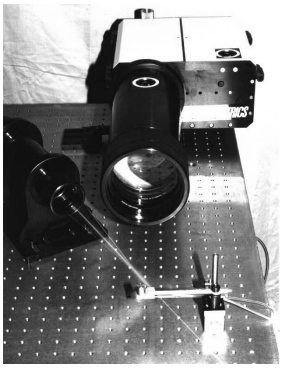
Small Business Innovation Research

Simultaneous Measurement of Temperature, Size, and Velocity of Drops in Sprays

Aerometrics, Inc.
Sunnyvale, CA

INNOVATION

An instrument which measures temperature, size and velocity of drops in sprays using rainbow refractometry/thermometry



ACCOMPLISHMENTS

- This laser-based, non-intrusive diagnostic instrument can measure temperature (refractive index) of individual spherical droplets in complex reactive sprays while simultaneously measuring size and velocity
- Applications have included burning droplet streams, swirl-stabilized spray flames, and multi-component non-reactive sprays

COMMERCIALIZATION

- Received orders for $500K worth of equipment in July 1995
- Sold to universities (Carnegie Mellon) for use on spray combustion studies
- Sold to aerospace industry for use in rocket injector studies
- Inquiries from Japan, China, France, and Korea
- Contributed to an expanded new location

GOVERNMENT/SCIENCE APPLICATIONS

- High Speed Research (HSR), Advanced Subsonic Transport (AST), icing and in rocket injector research and gas turbine combustion research
- Prototype rainbow thermometer delivered to Lewis and integrated with existing two component Phase Doppler Particle Analyzer

Glenn Research Center
Aeropropulsion

1989 Phase 2, NAS3-26248, SS-109; 3/29/96
NASA Contact - Mark Klem

Small Business Innovation Research

Single Lever Power Control for General Aviation and Unmanned Aircraft

Aurora Flight Sciences Corporation
Manassas, Virginia

INNOVATION

Pilot or Autopilot controls General Aviation or Unmanned Air Vehicle (UAV) propulsion system via a Single Lever or a Single Power Command using a FADEC (Full-Authority Digital Engine Control) with optimal propeller/engine control

ACCOMPLISHMENTS

- Developed first FADEC with full-digital Single Lever Power Control (SLPC) for General Aviation (GA) aircraft with optimal propeller/engine control
- Developed and flight-tested the SLPC-FADEC system in GA aircraft - showed over 20% fuel consumption improvement
- Tested FADEC system with UAV engine in test cell to 68,000 ft altitude
- FADEC-controlled engine propels the *Perseus B* high-altitude UAV to 60,000 ft altitude

COMMERCIALIZATION

- Joint ventures with Athena Technologies combines SLPC with advanced flight controls and FTC (Fault-tolerant Control) algorithms
- FADEC-controlled engines operated in excess of 500 hours in test cells and in flight
- Ideal propulsion control unit for General Aviation naturally aspirated and turbocharged singles, twins, turboprops and other transportation propulsion systems

Aurora's Chiron aircraft with full-digital Single Lever Power Control

GOVERNMENT/SCIENCE APPLICATIONS

- Currently being used in NASA's AGATE (Advanced General Aviation Transport Experiment) for integrated flight tests with all-digital cockpit technology components
- Potentially used in NASA's ERAST (Environmental Research and Atmospheric Science Technology) UAV program

Glenn Research Center
General Aviation
3-031

1994 Phase II, NAS3-27718, rev. 12/01
NASA Contact – Donald Simon
Company Contact – Tom Clancy

Small Business Innovation Research

Unstructured Adapted Meshes

Creare, Inc.
Hanover, NH

INNOVATION

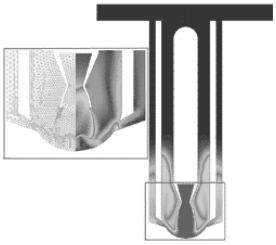
Computer software for the solution of compressible flows using unstructured grids

ACCOMPLISHMENTS

- Developed a general purpose computer program for computational fluid dynamics
- Unstructured solution-adaptive grids have been applied to a wide variety of problems including aircraft, turbomachinery, automobiles, internal combustion engines, missiles, parachutes, etc.

COMMERCIALIZATION

- Commercialized as the product RAMPANT™
- Well over $1M worth of licenses for RAMPANT™ have been sold
- Creare created a new software company, Fluent Inc. to market RAMPANT™ and several other CFD software products that were developed, in part, with NASA SBIR funding
- Fluent currently employs over 200 people and has annual revenues in excess of $30M. It was recently sold to Aavid Thermal Technologies, which is a large company



Mass fraction of exhaust gases and prediction of Mach number during confined launch of a rocket

GOVERNMENT/SCIENCE APPLICATIONS

- Solution of fluid flow problems and the design of flight vehicles using physical models that address turbulent flows, heat transfer, compressible mixing, chemical reaction, and flows with strong shocks

Glenn Research Center
Aeronautics
3-015

1987 Phase II, NAS3-25785, 8/98
NASA Contact - Rodrick Chima
Company Contact - Peg Ackerson

Small Business Innovation Research

Advanced CFD Tools for Designing Combustion Systems and Materials Processing

Daat Research Corp.
Hanover, NH

INNOVATION

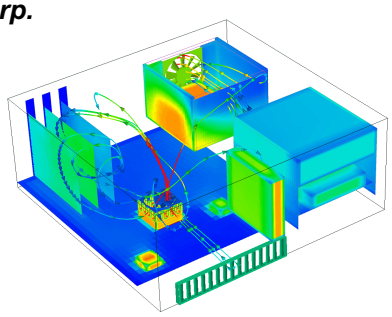
A fast, compact, PC-based code for analyzing combustion and materials processes

ACCOMPLISHMENTS

- A first of its kind, fast code for complex chemically reacting flows in arbitrary geometries
- Ability to run efficiently on MS-Windows PCs
- Custom versions developed for optimizing certain processes such as nozzle flows and fiber manufacturing for composites applications

COMMERCIALIZATION

- Based on the developed technology, Daat produced Coolit - a unique CFD code for electronics cooling applications
- Within two years, Coolit made major progress against well-entrenched competition increasing its sales exponentially and signing new clients world-wide
- Some of the world's best companies such as Boeing, Raytheon, Lockheed-Martin, Teradyne, ECT Telecom and many others now rely on Coolit for their thermal design needs



Example of Results for Electronics Cooling

GOVERNMENT/SCIENCE APPLICATIONS

- Highly compact and efficient code for designing and optimizing reactive flows in nozzles and in manufacturing processes for composite fibers
- Used in support of high speed research (HSR), and microgravity programs
- The commercial code, Coolit, is used in thermal design of electronics

Glenn Research Center
Aeronautics
3-028

1992 Phase II, NAS3-27251, 12/98
1992 Phase II, NAS3-27305
NASA Contact – Arnon Chait/Jeff Moder
Company Contact – Arik Dvinsky

Small Business Innovation Research

Improved Electroformed Structural Copper and Copper Alloys for Rocket Components

Electroformed Nickel, Inc.
Huntsville, AL

INNOVATION

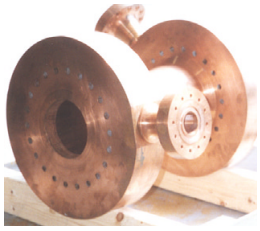
Improvements in mechanical properties of electrodeposited copper by conversion of coarse columnar grains into fine equi-axed grain structures and use of secondary strengthening methods such as alloying and dispersion strengthening

ACCOMPLISHMENTS

- Mechanical properties of electroformed copper equivalent to those of wrought nickel have been demonstrated (a 50% improvement over prior electroformed copper)
- Elevated temperature ductility of electroformed copper to 500°F has been improved three fold
- Copper-platinum and copper-silver alloys have been developed having potential for even higher temperature use
- A full scale regeneratively cooled copper tube bundle thrust chamber was fabricated entirely by electroforming with the new copper to demonstrate that property degrading thermal joining methods could be eliminated

COMMERCIALIZATION

- Aerojet has employed ENI's fine grained copper in the fabrication of full-scale formed platelet thrusters for Aerojet's Rocket Based Combined Cycle engine in support of Marshall Space Flight Center's Advanced Reusable Technologies Program. Aerojet is also investigating the use of ENI's fine grained copper for forming hotgas walls for combustion chamber liners.



NASA All Copper Compliant Tube Regen Chamber Electroformed using new High Strength Materials

- NASA Tech Brief articles of the new materials have been written and approved for publication.
- Have signed a contract with Pratt & Whitney for $100K for test samples for potential use in light-weight, high-performance reusable launch vehicles
- To date $17K of these new materials have been sold to NASA Lewis Research Center

GOVERNMENT/SCIENCE APPLICATIONS

- Dialogue continues with Boeing's Rocketdyne Division where Space Shuttle Main Engine upgrades are in planning
- Potential market will include DOD where new, improved shaped charge liners for warheads is sought

Glenn Research Center
Turbomachinery
3-020

1992 Phase II, NAS3-27386, rev. 2/00
NASA Contact – Tim Smith
Company Contact – Rich Edwards

Small
Business
Innovation
Research

Real-Time Sensor Validation

Expert Microsystems, Inc.
Orangevale, CA

INNOVATION

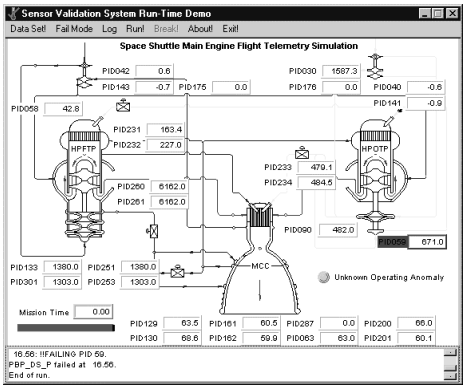
Real-time decision algorithm enables very high reliability sensor failure detection for safety critical control systems.

ACCOMPLISHMENTS

- Prototype system validates 15 Space Shuttle Main Engine (SSME) sensors in real-time
- SSME prototype reliably detects sensor failures from Start to Shutdown command
- Embedded in Boeing's Advanced Fault Tolerant Flight Computer and successfully tested
- Embedded in Lockheed-Martin's Modular Rocket Engine Control Software and successfully tested

COMMERCIALIZATION

- Follow-on contracts from NASA totaling $300,000 have created two full time equivalent jobs in 1997/98
- Commercial applications in chemical process and power generation industries anticipated



Space Shuttle Main Engine (SSME)
Real Time Sensor Validation

GOVERNMENT/SCIENCE APPLICATIONS

- Under development for real-time Space Shuttle telemetry data analysis and NASA mission operations support
- Under evaluation for military aeropropulsion system data monitoring

Glenn Research Center
Space Propulsion
3-012

1994 Phase I, NAS3-27484, 6/98
NASA Contact - June Zakrajsek
Company Contact - Randall Bickford

Small
Business
Innovation
Research

Ice Detection Sensor System

Innovative Dynamics, Inc.
Ithaca, NY

INNOVATION

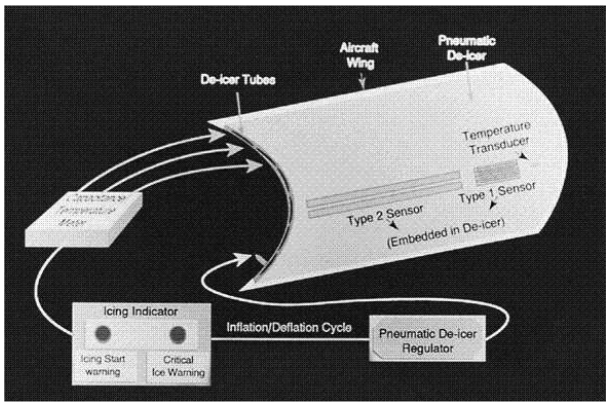
An integral sensor/de-icer system will enable pilots to validate de-icer inflation and to determine if accreted ice has shed after system operation

ACCOMPLISHMENTS

- The IDI sensor system will be integrated into B.F. Goodrich pneumatic de-icers to achieve significant advances in early ice detection, bringing ice detection technology to the general aviation market at an affordable price

COMMERCIALIZATION

- System has potential market value of $40-100M
- Market size of 20,000 to 50,000 general aviation aircraft
- Other applications include detection of ice on runways, highways, bridges, antennas and power lines
- B.F. Goodrich has acquired a license to the technology and patent rights for system



Automated ice protection system

GOVERNMENT /SCIENCE APPLICATIONS

- Research supported by Icing Technology Branch within NASA Lewis Research Center
- Piper Malibu featured at September 94 icing technology open house

Glenn Research Center
Icing Technology

1988 Phase 2, NAS3-25966, SS-34 10/17/95
NASA Contact - Andrew Reehorst

Small Business Innovation Research

Fiber Optic Cable Feedthrough and Hermetic Sealing for Aerospace Environment

LiteCom, Inc.
Canoga Park, CA

INNOVATION

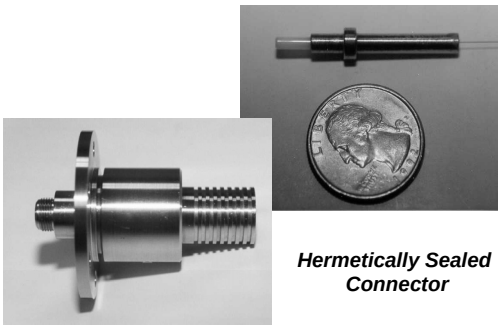
Fiber optic sealing material that provides cryogenic hermetic sealing up to 10^{-11} cc/sec Helium leak rate in both feedthroughs and connectors

ACCOMPLISHMENTS

- Designed and developed feedthroughs which demonstrated 10^{-11} cc/sec helium leak rate at temperatures from -196°C to +200°C
- Successfully used in vibration, thermal shock, salt spray, humidity, mechanical shock, neutron fluence radiation, gamma radiation, and ion radiation tests
- Created great interest in the commercial and military underwater applications for hermetic seals

COMMERCIALIZATION

- Hermetic sealing material development for fiber optic transmission between harsh environments such as refineries, nuclear power plants, aircraft, mines, security systems, petrochemical processing, ships, and corrosive environments
- Commercial sales - more than $1M
- Providing 5 jobs at LiteCom and its suppliers



Hermetically Sealed Connector

GOVERNMENT/SCIENCE APPLICATIONS

- Provided hermetically sealed underwater connectors for use with Navy submarines, submersibles, and remotely operated vehicles
- Provided fiber optic hermetic sealed connectors for Sandia Laboratory
- Potential for Space Station application

Glenn Research Center
Instrumentation and Controls
3-009

1990 Phase II , NAS3-26611, 5/98
NASA Contact - Amy Jankovsky
Company Contact - Robert Fan

Small Business Innovation Research

Special Coatings in a Rotary Engine

Moller International
Davis, CA

INNOVATION

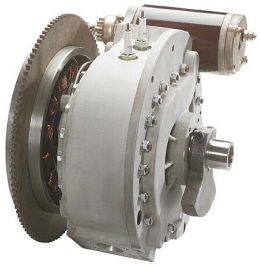
Special coatings, applied to rotary engines that will substantially improve specific fuel consumption, reduce wear and emissions, and have multi-fuel capabilities

ACCOMPLISHMENTS

- Tests by the California Air Resources Board proved the coated engine meets ultra-low emissions standards
- Endurance tests show that the time between overhaul can exceed 8,000 hours
- The Rotapower (Moller's trademark) engine has demonstrated its ability to operate on a variety of fuels – a truly multi-fuel engine

COMMERCIALIZATION

- Manufacturers have provided letters of intent for large quantities (over 500,000) of these engines. They are now conducting tests of the engines installed in their products
- Approximately $25 million in private funding has been applied to Rotapower engine development
- Huge markets for Rotapower engines have been identified in Asia and Mexico where air pollution is a major problem. A subsidiary firm, Freedom Motors, Inc., has been created for production and distribution
- Five patents are pending on various features of the engine
- The firm has 21 employees with six new positions created



Rotapower Engine

GOVERNMENT/SCIENCE APPLICATIONS

- Manufacturability of the Rotapower engine was significantly enhanced under a contract with the USAF Sacramento Air Logistics Center. A detailed manufacturing plan was developed and successfully tested
- A subsequent SBIR contract with the U.S. Army proved that the Rotapower engines operate very effectively using diesel fuel
- Potential government applications of Rotapower engines include powerplants for the Moller Skycar, a high-speed VTOL aircraft that has been the subject of numerous studies by the Army Battle Labs military applications includes MEDEVAC, search and rescue and fast logistic support

Glenn Research Center
Turbomachinery and Propulsion Systems
3-053

1989 Phase II, NAS3-26309, 8/00
NASA Contact – Chi-Ming Lee
Company Contact – Dr. Paul Moller

Small Business Innovation Research

Unsteady Triangular Mesh/Navier-Stokes Method for Aerodynamics of Aircraft with Ice Accretion

Nielsen Engineering & Research, Inc.
Mountain View, CA

INNOVATION

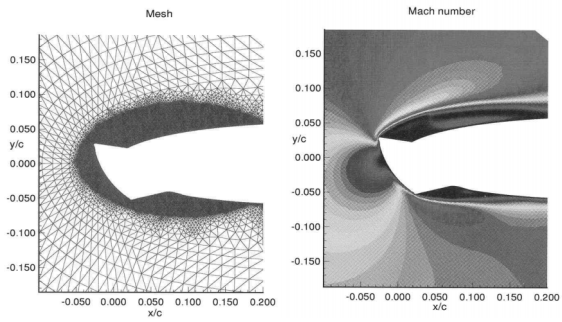
Combining an adaptive grid method with Navier-Stokes computer code for predicting ice growth on aircraft and performance degradation

ACCOMPLISHMENTS

- Developed computation capabilities to study effects of ice on the aerodynamics of aircraft wings

COMMERCIALIZATION

- Received $42K in direct sales
- Improved capabilities in an area that did not previously exist with the company; hence, company was able to obtain additional work



NACA 0012 Airfoil with Simulated Glaze Ice
$M_\infty = 0.12$, $\alpha = 4°$

GOVERNMENT/SCIENCE APPLICATIONS

- Useful in studies and design for commercial and general aviation for reducing ice accretion

Glenn Research Center
Aeronautics
3-030

1988 Phase II, NAS3-26059, 1/99
NASA Contact - Mark Potapczuk
Company Contact - Michael R. Mendenhall

Small Business Innovation Research

Metallized Cryogen for Advanced Hybrid Engines

Orbital Technologies Corporation
Madison, WI

INNOVATION

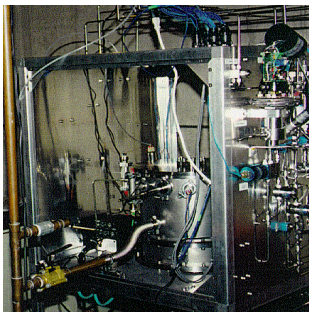
Storage and use of solid, cryogenic methane in an aluminum matrix as cryogenic rocket propellant with increased density, reduced vehicle weight and improved safety

ACCOMPLISHMENTS

- The feasibility of freezing a cryogen inside a metal matrix was demonstrated
- Storing solid methane in a configuration suitable for use in a hybrid engine was demonstrated
- A model for the freezing process was developed
- 25 successful hot test firings with gaseous oxygen, established baseline data on regression rates and other combustion data
- A patent was granted for this technology (#6101808)

COMMERCIALIZATION

- The technology of freezing cryogenic fluids and the freezing process model are useful commercially for storage and transport of cryogens
- Various aerospace companies have signed non-disclosure agreements with ORBITEC for use of this technology
- This technology has potential for in-space, In-Situ Resource utilization (ISRU), and launch propulsion systems



Advanced Cryogenic Hybrid Rocket Engine

GOVERNMENT/SCIENCE APPLICATIONS

- Received follow-on funding of $930K from the Air Force Research Laboratory and NASA Marshall for testing solid oxygen/liquid hydrogen
- Received a NASA Research Announcement contract from NASA Glenn for $490K to test solid carbon monoxide/liquid oxygen
- Received from NASA Goddard/Universities Space Research Assn. a Phase I & II NASA Institute for Advanced Concepts contract for $75K and $465K respectively, to compare solid methane/liquid oxygen, solid carbon monoxide/liquid oxygen, and other propellants

Glenn Research Center
Turbomachinery and Propulsion Systems
3-051

1992 Phase II, NAS3-27382, rev. 2/01
NASA Contact – Bryan Palaszewski
Company Contact – Eric E. Rice

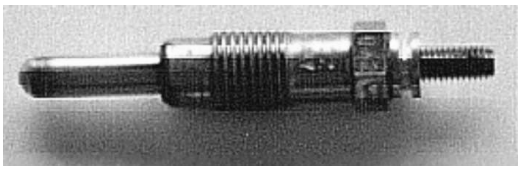
Small
Business
Innovation
Research

Catalytic Ignition for Rotary Combustion Engines

Precision Combustion
New Haven, CT

INNOVATION

Catalytic glow plugs and catalytic surface technology for internal combustion engines and gas turbines



Glowplug

ACCOMPLISHMENTS

- Significantly reduced gaseous and white smoke emissions in rotary engines, as well as improved efficiency and stability
- Demonstrated durability advantages of catalytic glow plugs vs. conventional glow plugs
- Proved concept of using catalytic engine coatings under severe thermal fatigue

COMMERCIALIZATION

- Advances in program led to developments in catalytic ignition systems receiving $2.6M in further R&D investment from both government and commercial sources
- Precision Combustion, Inc. is working with major diesel engine manufacturers to implement catalytic glow plugs for new engine design, with Phase III investment more than $300K
- Company increased in size from 1 employee to 5 employees

GOVERNMENT/SCIENCE APPLICATIONS

- Technology enabled further catalytic combustor advances by Precision Combustion, Inc. for DARPA, NASA, US Army, and USAF
- Catalytic ignitors for improved combustion stability to prevent flame out during rapid acceleration and deceleration of aircraft engines
- Catalytic combustors for ultra-low emission gas turbine engines

Glenn Research Center
Aeropropulsion

1986 Phase 2; NAS3-25784, SS-160; 3/24/97
NASA Contact - Chi Ming Lee

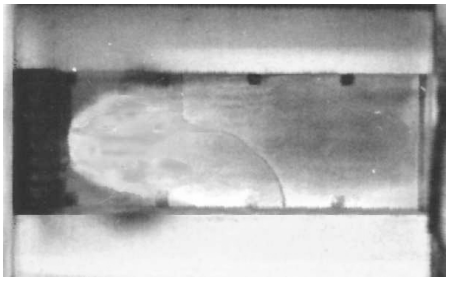
Small
Business
Innovation
Research

A Novel Approach to Catalytic Combustion

Precision Combustion
New Haven, CT

INNOVATION

Advanced catalytic conbustor for aeropropulsion and ground based engines



Catalytic Combustion Flame

ACCOMPLISHMENTS

- Demonstrated Ultra-low No_x, CO, and Unburned Hydrocarbons (UHC) emissions for High Speed Civil Transport applications
- No_x emissions were demonstrated at steady-state to be 1/3 to 1/5 of regulatory targets

COMMERCIALIZATION

- Multimillion dollar long term catalytic combustor development and supply agreement between Westinghouse Power Generation and Precision Combustion, Inc
- Precision Combustion Inc.'s catalytic combustor for Equivalent Zero Emission Vehicles is in an automotive application engine test program with Capstone Turbine Corporation
- Non-government Phase III funding of more than $500K for ultra-low NOx emissions catalytic combustors for ground base gas turbine hybrid electric vehicles
- Employment increased from 5 to 30 employees

GOVERNMENT/SCIENCE APPLICATIONS

- Ultra-low NOx aircraft and ground power catalytic combustion
- Catalytic combustors for clean hybrid electric vehicles
- Ignition and combustion stability enhancement for aerospace engines

Glenn Research Center
Aeropropulsion

1990 Phase II, NAS3-26614, SS-161; 3/97
NASA Contact - Chi Ming Lee

Small
Business
Innovation
Research

Turbo with Automatic Zoning (GridPro)

Program Development Company
White Plains, NY

INNOVATION

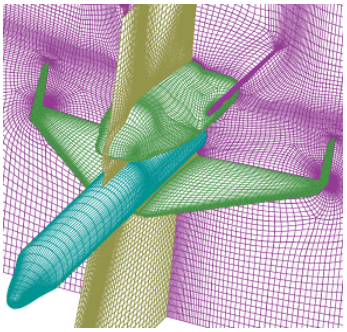
A multiblock grid generation program that is automatic once the pattern of grid blocks is given. The user supplies the pattern without a great need for precision

ACCOMPLISHMENTS

- Developed multiblock grid generation software system. The resulting grid is optimized to be smooth and orthogonal throughout the volumetric region and to be clustered about the locations of concave and convex boundary curvature
- Integrated the grid software with the NASA CFD codes GlennHT and WIND
- Provided the critical link for high fidelity CFD analysis to be applied to realistic configurations for industry and government applications

COMMERCIALIZATION

- The software is called **GridPro** and is being used by many industrial companies in the world. These include Solar Turbines, Concepts-Northern, General Dynamics, Parker Hannifan, Grundfos, Ford Motor, Dow Chemical, Toshiba, Mitsubishi, European Space Agency, etc.
- Further commercialization can be obtained from website, www.gridpro.com



Grid for Two-Stage to Orbit Vehicle

GOVERNMENT/SCIENCE APPLICATIONS

- **GridPro** has been purchased for use by NASA Glenn Research Center and Ames Research Center
- For at least five years, Glenn Research Center has paid the company $20K per year for a total of $100K for upgrade and maintenance of this software
- Academic customers include Penn State, Rutgers, Rice, Illinois, Stanford, Ohio State Supercomputer Center, Utah State, Cambridge, Stuttgart, Delft, Aachen, Greenwich, etc.

Glenn Research Center
Turbomachinery and Propulsion Systems
3-052

1989 Phase II, NAS3-26311, 8/00
NASA Contact – Ray Gaugler
Company Contact – Peter R. Eiseman

Small
Business
Innovation
Research

Flow in Turbine Blade Passages

Scientific Research Associates, Inc.
Glastonbury, CT

INNOVATION

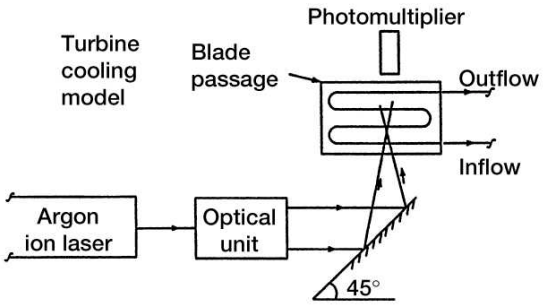
The use of refractive index matching laser velocimetry to obtain detailed mean and turbulent flow fields

ACCOMPLISHMENTS

- Obtained knowledge of flow fields required to achieve goals
- Flow field measurements provided a nice compliment to previously acquired heat transfer from a model of similar geometry
- Simulations were compared to experimental velocity fields
- Combined computational-experimental program provided new insight into structure of flow field

COMMERCIALIZATION

- Generated $240K in Government Non SBIR/STTR Funds
- UTRC collaborated in the program by providing model geometry and heat transfer data
- Pratt and Whitney performed the computational calculations



Laser-Doppler Velocimeter Set-up - Forward Scattering

GOVERNMENT/SCIENCE APPLICATIONS

- New design tool for the development of turbine blade internal cooling configurations
- Rotating flow field database useful for simulation code validation

Glenn Research Center
Aeronautics
3-013

1989 Phase II, NAS3-26251, 5/98
NASA Contact - Philip Poinsatte
Company Contact - Dr. Harold L. Grubin

Small
Business
Innovation
Research

Autonomous Leak Detector for Orbiting Spacecraft

SI Diamond Technology, Inc.
Austin, TX

INNOVATION

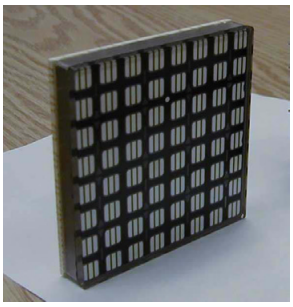
A Time-of-Flight Mass Spectrometer (TOF-MS) design that employs continuous ionizations. Continuous ionization requires less power than the usual pulsed ionization

ACCOMPLISHMENTS

- Using this innovation a leak detection was built to monitor in-orbit leaks in spacecraft
- The TOF-MS from this innovation was used to monitor impurities in materials. Although the SBIR was awarded to Schmidt Instruments, Inc., most of this development was done after a name change to SI Diamond Technology, Inc.

COMMERCIALIZATION

- Using this TOF-MS, SI Diamond Technology, Inc. developed the capability to monitor impurities in thin film diamond. As a result they refocused the company to diamond technology
- The thin film diamond technology is expected to be used in large flat screen displays for various digital advertising applications



High Definition Picture Element Tube (PET-HD)

GOVERNMENT/SCIENCE APPLICATIONS

- The University of Houston's "Space Vacuum Epitaxy Center" purchased two TOF-MS for use in the "Weight Shield Facility Program"
- As part of the "Weight Shield Facility Program" the TOF-MS flew on three Shuttle flights in a control loop to monitor atomic oxygen and atomic hydrogen impurities for a process to improve thin film gallium arsenide production. The Shuttle flights were STS-60 (Discovery, Feb. 94), STS-69 (Endeavor, Sept. 95), and STS-80 (Columbia, Nov. 96)

Glenn Research Center
Turbomachinery and Propulsion Systems
3-047

1988 Phase II, NAS3-25971, 3/00
NASA Contact – Todd Tofil
Company Contact – Zvi Yaniv

Small
Business
Innovation
Research

Gas Turbine Combustor for Low Pattern Factor and Low NOx Emissions

SOL-3 Resources, Inc.
Reading, MA

INNOVATION

Combustor design based on bulk swirl variable residence time concept. This innovation eliminates compressor exit vanes and reduces combustor and turbine nozzle part counts while reducing emissions and pattern factor

ACCOMPLISHMENTS

- Combustor rig tests at Allison and Allied Signal have demonstrated the following advantages for this combustor design concept:
  - Low NOx, CO, and unburned hydrocarbon emissions
  - Reduces hardware parts count
  - Provide a low pattern factor, low pressure loss, and cooler walls
  - Provide very high altitude combustion stability

COMMERCIALIZATION

- Private capital is being used to continue development and make engine manufacturers in the U.S. and Europe aware of the benefits of this technology

SOL-3 Resources, Inc. Combustor

GOVERNMENT/SCIENCE APPLICATIONS

- This NASA SBIR served as a stepping stone for successful Army Phase I & II contracts
- Following the Army SBIR an Air Force SBIR was successfully completed. This has resulted in discussions with the Air Force for a potential Phase III

Glenn Research Center
Turbomachinery
3-049

1988 Phase II, NAS3-26057, 4/00
NASA Contact – Robert Tacina
Company Contact – Jerry Melconian

Small Business Innovation Research

High Temperature Oxidation-Resistant Thruster Materials

Ultramet
Pacoima, CA

INNOVATION

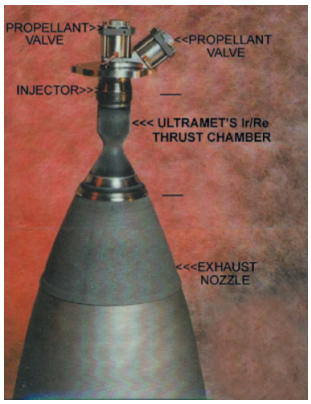
Application of material and processing science to permit liquid propellant rocket engines to operate 600°C hotter: iridium-lined rhenium chambers fabricated by chemical vapor deposition (CVD)

ACCOMPLISHMENTS

- Advanced the state-of-the-art in materials and processes for the fabrication of liquid bipropellant chemical rocket thrust chambers, permitting 3-5% increase in productivity (e.g., life and performance)
- Flight qualified and successfully flown in space on the Hughes Orion 3 spacecraft
- Operates at hotter temperature without fuel-film cooling; hence a 10-20 second increase in specific impulse, resulting in lower fuel consumption

COMMERCIALIZATION

- NASA, TRW/Lockheed Martin, Kaiser Marquardt/Hughes, Kaiser Marquardt/Loral, Aerojet and Ultramet have invested nearly $25M to develop this technology
- Production orders for chambers received from numerous satellite manufacturers
- Received $568K in Phase III funding from the On-Board Propulsion Branch at NASA Glenn



Flight Engine

GOVERNMENT/SCIENCE APPLICATIONS

- Through increased thruster performance, communications satellite owners/operators will realize $30-60M in added revenue per satellite
- Apogee kick and station-keeping thrusters for satellites in geostationary orbit and thrusters for spacecraft propulsion systems
- Rocket nozzles, turbomachinery and aircraft turbine engine components

Glenn Research Center
Materials
3-042

1985 Phase II, NAS3-25203, rev. 11/99
NASA Contact – Steve Schneider
Company Contact – Robert Tuffias

Small Business Innovation Research

High Temperature Turbine Blades

Ultramet
Pacoima, CA

INNOVATION

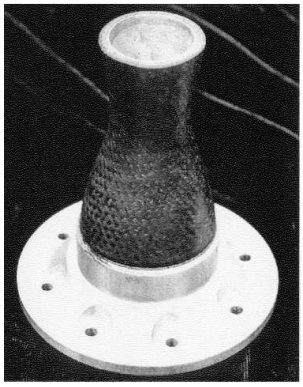
Net-shape fiber-reinforced metal matrix composite turbine blades, produced by a unique chemical vapor infiltration (CVI) process

ACCOMPLISHMENTS

- Evaluated continuous refractory fibers as strengthening reinforcements for niobium metal matrix
- Developed controllable, repeatable process for infiltrating niobium metal matrix into fiber preforms
- Ultimately spun off technology into fabrication of load-bearing, hermetically sealed ceramic-to-metal joints for use in high temperature propulsion systems

COMMERCIALIZATION

- Ceramic-to-metal joints fabricated for BMDO/Army Theater High Altitude Air Defense System (THAADS), with $750K in sales to date to propulsion contractor (Rocketdyne)
- Ceramic-to-metal joints fabricated for DOE/Navy submarine nuclear reactor program, with $500K in sales to date to industry contractor (GE/Knolls Atomic Power Laboratory)
- To date, 3 new jobs have been created at Ultramet



Ceramic Composite Thrust Chamber with Metal Flange Attachment

GOVERNMENT/SCIENCE APPLICATIONS

- Aerospace propulsion and power systems, including intercept vehicles for missile defense, nuclear submarine reactors, advanced aircraft turbine engines and liquid rocket turbomachinery

Glenn Research Center
Materials

1987 Phase II, NAS3-25650, SS-178, 8/97
NASA Contact - John Kazaroff

STRUCTURES

Small
Business
Innovation
Research

Large Area Detector for Radiographic Measurements

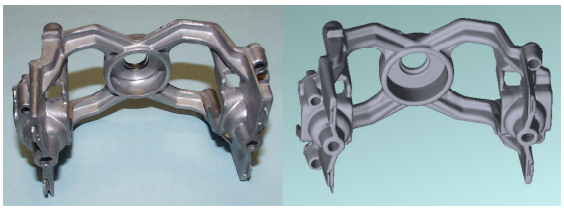
Advanced Research and Applications Corporation
Sunnyvale, CA

INNOVATION

An imaging detector system for non-destructive evaluation that has greater resolution, higher contrast sensitivity and wider dynamic range

ACCOMPLISHMENTS

- Developed scatter-rejection techniques that resulted in 98 percent improvement in contrast and 40 percent improvement in detective quantum efficiency
- Developed prototype detector and integrated it into a real-time radiography system for observing materials while stressed in a load frame



Aluminum casting (left) and the corresponding volumetric 3D image

COMMERCIALIZATION

- Detector technology incorporated into the Konoscope™ volumetric x-ray computed tomography systems
- Konoscope™ sales have reached almost $2,500,000. These are to Wright Patterson Air Force Base and the University of Utah

GOVERNMENT/SCIENCE APPLICATIONS

- Useful in development of advanced composite materials and in rapid prototyping/reverse engineering
- For use in dimensioning of complex parts

Glenn Research Center
Structures
3-060

1991 Phase II, NAS3-26986, 11/00
NASA Contact – George Baaklini
Company Contact – Robert Frankle

Small
Business
Innovation
Research

Design of Experiments Module

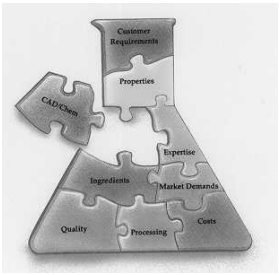
AI Ware, Inc.
Cleveland, OH

INNOVATION

A general purpose computational method using artificial intelligence that selects experiments required to develop a design model

ACCOMPLISHMENTS

- Developed a Design of Experiments module for enhanced computational methods
- Scientific community recognized this product as a very useful contribution for re-designing experiments and hence reducing experiment costs
- Company was selected by readers of R&D magazine as a winner in the 1994 R&D ELITE Awards Program



Design of Experiments Module

COMMERCIALIZATION

- Experiments module is tentatively scheduled for commercial release in mid-1995 along with the introduction of CAD/Chem Version 4.2
- Diverse customer base includes: pharmaceuticals & medical (Eli Lilly and Company), chemicals (S.C. Johnson Wax), , plastics (B.F. Goodrich & Dow Chemical), paint & coatings (The Glidden Paint Company)
- Contributed $100K to sales, and this contribution is increasing

GOVERNMENT/SCIENCE APPLICATIONS

- The computer program which incorporates artificial intelligence can be applied to any experimental designing used in the scientific and research communities
- This method is presently being used in Lewis Research Center's Structural Analysis program
- Also used at Wright Patterson AFB in the composites area

Glenn Research Center
Structures

1990 Phase 2, NAS3-26657, SS-27, 8/2/96
NASA Contact - Laszlo Berke

Small Business Innovation Research

Concurrent Probabilistic Simulation of High Temperature Composite Structural Response

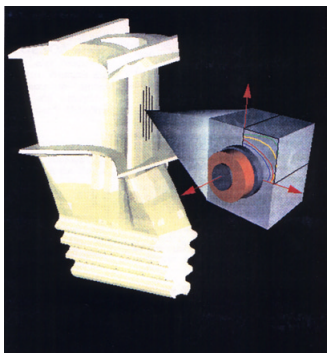
Alpha STAR Corporation
Long Beach, CA

INNOVATION

A superior multipurpose resource for the design and analysis of composite structures

ACCOMPLISHMENTS

- Memory limitations was removed from the technology for composite mechanics
- System optimization by parallel distribution of work load achieved minimum computer solution time
- Greatly increased the computer program processing speed and facilitated data transfer
- Concurrent probabilistic simulation of large scale material and structures analysis predicted life uncertainties
- Made possible visualization of composite structures
- Placed performance and analytical capabilities directly into the hands of the engineer



Space Shuttle Turbine Blade

COMMERCIALIZATION

- As one of the initial contracts for this technology, it served as a major stepping-stone that resulted in a significant commercial product
- Commercialized under the trade name GENOA. Had steadily increased revenue since 1996
- Provided industrial training for this software system

GOVERNMENT/SCIENCE APPLICATIONS

- This software system has been used by NASA, USAF, and FAA

Glenn Research Center
Material and Structures
3-061

1991 Phase II, NAS3-26997, 11/00
NASA Contact – Christos Chamis
Company Contact – Kay Matin

Small Business Innovation Research

GENOA/Progressive Failure Analysis (GENOA/PFA) Software System

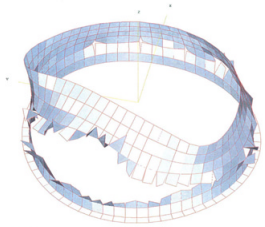
Alpha STAR Corporation
Long Beach, CA

INNOVATION

Analysis & simulation tool to evaluate aerospace structure integrity, durability, reliability, aging & manufacturing without using traditional fracture mechanics parameters

ACCOMPLISHMENTS

- Damage tolerance evaluation of structural elements made from all types of composites and metals
- Impact resistance evaluations of composite engine structures
- Durability evaluations of metal joints and prototype structures
- Verified excellence in analysis of composite materials
- Received NASA Software of the Year Award for 1999, R&D 100 Award for 2000



Ceramic Matrix Composite Turbine Engine Combustor GENOA/PFA Damage Tolerance Evaluation

COMMERCIALIZATION

- Software commercialized since 1998 for site leases and for problem solving
- Alpha STAR Corporation has six full time employees who support software development and provide industrial training and support on user requests
- Annual revenues from commercial usage has reached $2M
- Boeing South - Damage tolerance of airframe components
- Boeing North - Mini Space Maneuverable Vehicle (SMV) fracture evaluation of verification testing
- Honeywell Allied Signal - Ceramic Composite Combustors
- STI Optronics - Laser platform made from composite sandwich
- GE & Goldsworthy - Alternative low-cost net shape composite manufacturing

GOVERNMENT/SCIENCE APPLICATIONS

- NASA White Sands - Filament wound pressure vessels
- NASA LaRC - Composite components for airframes
- NASA GRC - Damage tolerance of composite containment engine structures
- USAF - Microstresses in composites
- FAA - Negotiations damage tolerance retrofits of aging aircraft structures
- NIST - Evaluation of composite structures for infrastructure

Glenn Research Center
Structures
3-048

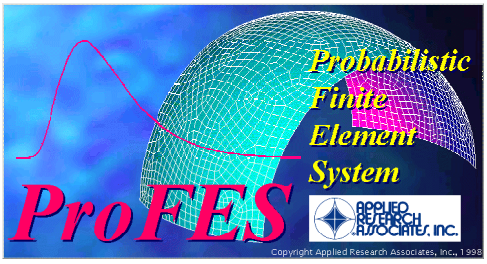
1995 Phase II, NAS3-97041, rev. 8/01
NASA Contact – Chris Chamis
Company Contact – Frank Abdi

Small Business Innovation Research

Portable Parallel Stochastic Optimization for Aeropropulsion Component Design

Applied Research Associates
Raleigh, NC

INNOVATION
Synergistic fusion of innovative design methods and computing for optimized aeropropulsion components



ACCOMPLISHMENTS

- Demonstrated a breakthrough in computer-based design capabilities for aeropropulsion components
- Improved the program to make it user friendly

COMMERCIALIZATION

- Obtained a 750K Air Force SBIR contract to make program more user friendly
- Received 25K contract from Langley Research Center for special program customization
- Sold commercially six copies of the program for 10K
- Continuing the marketing of the program

GOVERNMENT/SCIENCE APPLICATIONS

- Applicable for designing components for the next generation of aircraft engines and spacecraft propulsion

Glenn Research Center
Structures
3-64

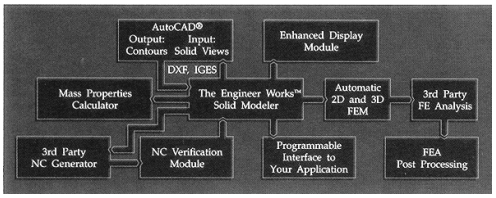
1992 Phase II, NAS3-27288, 4/01
NASA Contact – Dale Hopkins
Company Contact – Robert H. Sues

Small Business Innovation Research

Autosolid

Cadetron, Inc.
Atlanta, GA

INNOVATION
An expert system that utilizes CAD capabilities to create a finite element model for use by those who are not experts in Finite Element analysis



Information Flow of Finite Element Analysis

ACCOMPLISHMENTS

- A solid modeler was developed and integrated with an internal advisory expert system to automatically transform it into a finite element model and to perform structural analysis

COMMERCIALIZATION

- The product caught the interest of AUTODESK, the world's largest CAD/CAM software company before the contract end date and they bought Cadetron
- The solid modeler was first released as AUTOSOLID then as the "Advanced Modeling Extension" (AME) to the AutoCAD product. Sales of this product resulted in several million dollars of revenue.

GOVERNMENT/SCIENCE APPLICATIONS

- Has been used in NASA Lewis's structural analysis research
- Innumerable applications for product design within the AutoCad system

Glenn Research Center
Structures
3-008

1985 Phase 2; NAS3-25150 SS-125; 3/12/98
NASA Contact - Laszlo Berke
Company Contact - Robert Holt

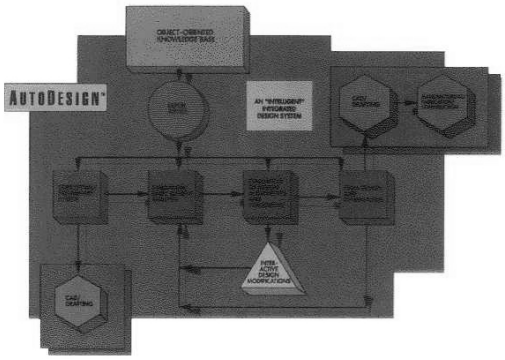
Small
Business
Innovation
Research

AUTODESIGN

Structural Analysis Technologies, Inc.
Santa Clara, CA

INNOVATION

Integration of solid modeling, structural analysis/optimization with Expert System Advisor



AUTODESIGN architecture

ACCOMPLISHMENTS

- AUTODESIGN is a structural optimization and design software which is unique in the market because of its Expert System knowledge based content

COMMERCIALIZATION

- Structural Analysis Technologies has partnered with AUTODESK, the world's largest CAD/CAM software company, to market AUTODESIGN
- Approximately 500 copies were sold by Structural Analysis Technologies, with sales totaling nearly $2 M
- SAT, together with AUTODESK are part of the winning team for the $900 M Navy NAVFAC software contract. SAT's portion of the contract is $5M with a maximum up to $7M.

GOVERNMENT/SCIENCE APPLICATIONS

- Used at Lewis Research Center and Edwards AFB in design of new generation aerospace structures
- Used by Hughes Aircraft, TRW, Applied Materials, Lockheed, Sandia Labs, and Kelly AFB, as well as other firms and government organizations for mechanical and aerospace design

Glenn Research Center
Structures

1987 Phase II, NAS3-25642, SS-28, 8/20/97
NASA Contact - Laszlo Berke

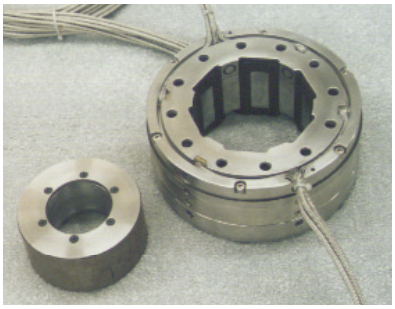
Small
Business
Innovation
Research

Magnetic Bearing System for Gas Turbine Engine

Synchrony Inc.
Roanoke, Virginia

INNOVATION

High Temperature, Fault-Tolerant Magnetic Bearing and Monitoring System



Rotor and Stator of Magnetic Bearing

ACCOMPLISHMENTS

- Demonstrated actuator performance to 1100° F
- Demonstrated adaptive, inertial balance control system to 12,000 rpm
- Successful demonstration of fault-tolerance operation
- Demonstrated innovative capacitance sensor to 1100° F
- Demonstrated monitoring system for rotordynamic health of machine, including estimation of size and location of unbalance.

COMMERCIALIZATION

- Commercial sales of magnetic bearings - $612,500 to Rolls-Royce Allison, General Electric, Lion Precision
- Strategic alliance with Rolls-Royce Allison to develop gas turbine engines with magnetic bearings
- Spin-off industrial controls company with cumulative revenues exceeding $6 million

GOVERNMENT/SCIENCE APPLICATIONS

- Technology is currently used in Department of Defense programs to develop Advanced Turbine Engine Gas Generator (ATEGG)
- Applicable to future More Electric Engine programs for manned and unmanned aircraft
- Magnetic bearings suitable for industrial compressors, pumps, fans, motors, metal-forming machinery

Glenn Research Center
Structures
3-078

1993 Phase II, NAS3-27551, 12/01
NASA Contact – Gerald Brown
Company Contact – Victor Iannello

Small Business Innovation Research

High Reliability Long-Term Lubricators

The Technology Partnership
Grosse Ile, MI

INNOVATION

Dispensing lubricant for multi-year durations using the viscoelastic effects of polymers

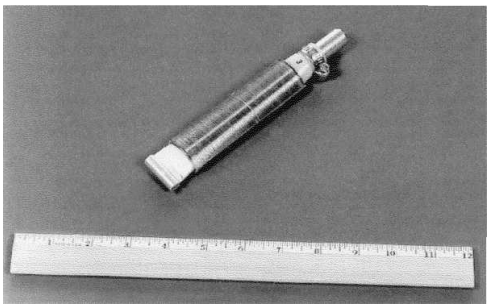


Photo courtesy of TACOM - Glen Steele
Shrink-Polymer Dispenser

ACCOMPLISHMENTS

- Developed long term time-dependent shrink-polymers for dispensing lubricants
- Validated a new use for shrink-polymers as implants for long term drug-infusion pumps
- Patents obtained for new shrink-polymer applications

COMMERCIALIZATION

- A major automotive supplier has committed for $500K in follow-on funding for an annual automotive market estimated at $100M annually
- Major drug companies are evaluating a universal drug-dispensing implant that uses viscoelastic technology
- Subsequent Phase I and II SBIR awards from both Army Tank automotive and Armaments Command (TACOM) and the Air Force based on shrink-polymers

GOVERNMENT/SCIENCE APPLICATIONS

- Assured lubrication of satellite spin-motors with 80% reduction in lift weight over mechanical lubricators
- Lubricator has the potential to make substantial improvements in maintenance costs and reliability of U.S. Army tactical vehicles

Glenn Research Center
Materials

1992 Phase I, NAS3-26844, SS-181, 8/97
NASA Contact - Robert Fusaro

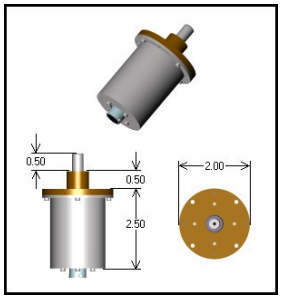
Small Business Innovation Research

A Low-Cost, Compact, Non-Explosive Pin-Puller for Aerospace Applications

TiNi Alloy Company
San Leandro, CA

INNOVATION

A non-explosive “Pinpuller and Rotary” actuator employing shape memory alloys (SMA)



Pinpuller - Model P25-810-1.5R

ACCOMPLISHMENTS

- Developed an actuating mechanism by harnessing the recovery characteristics of SMA
- Developed a SMA trigger mechanism which allows for fast (milli-second) actuation
- Flight qualified several embodiments prior to the end of Phase II funding
- Patented trigger mechanism based on SMA technology

COMMERCIALIZATION

- An SMA actuator was used to successfully deploy solar arrays for the Clementine Spacecraft
- This technology expanded company’s aerospace product line sufficiently to enable them to spin off a new company called TiNi Aerospace, Inc.
- TiNi Aerospace’s production of aerospace release mechanisms grew to several hundred flight articles per year with sales revenue exceeding $1M per year

GOVERNMENT/SCIENCE APPLICATIONS

- Applications include “Hold Down and Release” of numerous satellite deployables including solar panels, communication antennae, instrument cover doors, radiators, heat shields, tether experiments, isolation system and numerous others
- Used aboard the Mars Global Surveyor, Lunar Prospector and numerous others

Glenn Research Center
Structures
3-039

1992 Phase II, NAS3-27292, rev. 2/02
NASA Contact – Douglas Rohn
Company Contact – Michael Bokaie

MICROGRAVITY

Small Business Innovation Research

High Temperature Thermophysical Property Measurements in Microgravity

Containerless Research, Inc.
(formerly Intersonics, Inc.)
Evanston, IL

INNOVATION

Precise and accurate non-contact measurements of the properties of molten materials in highly controlled containerless conditions

Electromagnetically levitated liquid metal

ACCOMPLISHMENTS

- Developed facility and techniques for non-contact property measurements of emissivity, surface tension and heat capacity on molten metals, alloys, and dielectrics
- Developed software tools for analysis of materials property data for process modeling applications (with Auburn University)

COMMERCIALIZATION

- Commercial sales exceed $100K. Further business pending
- New capabilities have leveraged access to instrumentation and materials processing markets with revenues over $1M
- Trained and employed engineers and scientists in development of new products as a result of leveraged activities
- Commercial clients include the metal casting, glass, fiber optic and semiconductor industries

GOVERNMENT/SCIENCE APPLICATIONS

- Basic research on materials properties leads to better materials, improved performance, energy savings, and safety, which is important in designing advanced materials and in experiment design
- Control of fluid motion needed to make accurate measurements of thermophysical properties in liquids is possible in low gravity. This is one of NASA's key materials research areas

Glenn Research Center
Microgravity
3-054

1991 Phase II, NAS3-26898, 9/00
NASA Contact – Emily Nelson
Company Contact – Richard Weber

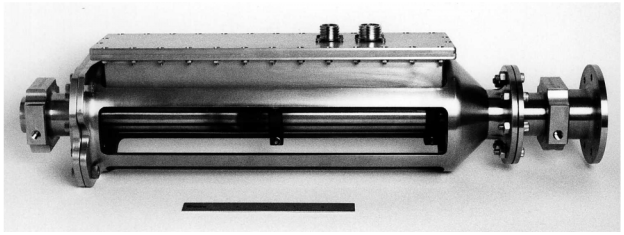
Small Business Innovation Research

A Capacitive Void Fraction Instrument for Two-Phase Flow in Microgravity

Creare, Inc.
Hanover, NH

INNOVATION

Non-intrusive instrument for measurement of volume-averaged or local void fraction with refrigerants (dielectric fluids)



Space-Qualified Version of Creare Void Fraction Instrument

ACCOMPLISHMENTS

- Proved non-intrusive design approach
- Developed stable, accurate electronics and signal conditioning
- Demonstrated instrument on microgravity aircraft
- Space-qualified instruments delivered
- Continuing to support microgravity aircraft flights in 1998/99 (KC-135) with the design/development of instruments of various internal diameters

COMMERCIALIZATION

- Sold approximately $500K worth of these instruments to NASA for various science missions to date
- Instrument can be used in a gravity environment. Have had negotiations with some companies for use in gravity

GOVERNMENT/SCIENCE APPLICATIONS

- Used in microgravity science missions aboard the NASA KC-135 aircraft:
  – To measure flow characteristics (local/avg. void fractions and wall shear stress) in a R-134a refrigerant loop by NASA LeRC Microgravity Division
  – To measure flow characteristics in R-134a and R-12 refrigerant loops by NASA JSC Crew and Thermal Systems Division (with Texas A&M University)

Glenn Research Center
Microgravity
3-014 CD-98-77710

1991 Phase II, NAS3-26552, 7/98
NASA Contact - Myron Hill
Company Contact - Christopher J. Crowley

Small
Business
Innovation
Research

Numerical Simulations of Transport Processes

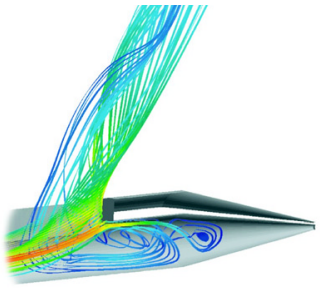
Fluent, Inc. (formerly Fluid Dynamics, Inc.)
Lebanon, NH

INNOVATION

Incorporating diverse transport phenomena on space and terrestrial processes using new and innovative numerical algorithms into a state-of-the-art code. This will enable the computations of free surfaces in multidimensions

ACCOMPLISHMENTS

- Successfully incorporated new numerical algorithms into a state-of-the-art FIDAP code (Computational Fluid Dynamics Analysis Package)
- Enhanced the FIDAP code by adding free surface, heat transfer, stability analysis and magnetic field effects
- Simulations of complex transport phenomena were proven



FIDAP CFD Simulation of Flow Pathlines in a Biomedical Needle Device

COMMERCIALIZATION

- Used by industry, the FIDAP code is used to predict and design experiments and processes
- Additional capabilities added through SBIR have made FIDAP the premier tool for computation of transport phenomena in materials processing applications
- Fluid Dynamics, Inc. was purchased by Fluent Inc. in 1996 and is now part of Fluent

GOVERNMENT/SCIENCE APPLICATIONS

- Used for many microgravity process problems, including thermocapillary connection, crystal growth, magnetic damping, and free surface processes
- Useful in any process design problems

Glenn Research Center
Microgravity/Materials
3-050

1988 Phase II, NAS3-25946, 4/00
NASA Contact – Arnon Chait
Company Contact – Keith Hanna

Small
Business
Innovation
Research

Near-Infrared Diode Laser Microgravity Combustion Diagnostic

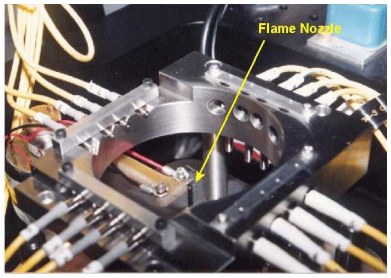
Southwest Sciences, Inc.
Santa Fe, NM

INNOVATION

First Quantitative Combustion Gas Concentration Measurements in Microgravity

ACCOMPLISHMENTS

- Developed laser-based gas sensor suitable for drop tower and space-based measurements



Diode Laser System Showing Fiber Jig and Burner Mounted on Drop Rig

COMMERCIALIZATION

- Technology licensed to Ametek and a second commercialization partner; sales to date over $2.3M
- Revenues from licensing over $300,000
- Technology used for perimeter monitoring of hazardous gases in refineries, for measurement of chemical process streams, and for detecting impurities in semiconductor manufacturing gases
- Two full time jobs resulted from this innovation

GOVERNMENT/SCIENCE APPLICATIONS

- This system is currently being used by NASA to measure combustion gas concentrations in its drop tower facility at NASA Glenn Research Center. Newer systems now under development could be used in the International Space Station and other spacecraft for both research studies and as fire safety monitors
- This SBIR effort has led to additional government and private sector funding for both research and individual instruments for atmospheric and combustion monitoring

Glenn Research Center
Microgravity Science
3-036

1991 Phase II, NAS3-25981, 5/99
NASA Contact – Paul S. Greenberg
Company Contact – Dr. Joel A. Silver

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This booklet of success stories highlights the NASA Glenn Research Center's accomplishments and successes by the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs. These success stories are the results of selecting projects that support NASA missions and also have high commercialization potential. Each success story describes the innovation accomplished, commercialization of the technology, and further applications and usages. This booklet emphasizes the integration and incorporation of technologies into NASA missions and other government projects. The company name and the NASA contact person are identified to encourage further usage and application of the SBIR developed technologies and also to promote further commercialization of these products.

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